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BELFAST MEETING

September 3–10, 1952

By a happy coincidence the 114th Annual Meeting of the Association was held in Belfast, under the presidency of Professor A. V. Hill, on the 100th anniversary of the first meeting and the 50th anniversary of the third meeting in that hospitable city. Thus, to the normal interest of the B.A. week was added a sense of historic occasion.

The meeting was memorable in other ways. To all but the local members and welcome visitors from Eire, it was an overseas meeting. To many it offered the opportunity for a first (and in some instances, a long-desired) visit to Ireland : and the visiting members rejoiced with the people of Ulster in the timely decision by H.M. Government of the United Kingdom to abolish travel permits. The proceedings were graced on the opening day by the presence of H.R.H. The Duke of Edinburgh, and the meeting was held under the local, and active, patronage of the Prime Minister of Northern Ireland. The attendance of 4,600 registered members exceeded by about 600 the record-breaking attendance at the Edinburgh Meeting in the year of the Festival of Britain in 1951 ; and the membership included over 1,000 junior members, of whom the majority were local children generously given leave of absence from school by the Minister of Education for Northern Ireland.

The unusually large attendance reflected the measure of local enthusiasm which was most generous from the beginning of local preparations and continued unabated to the end of the meeting.

The President's first duty was, with the Chancellor and Vice-Chancellor, to receive H.R.H. The Duke of Edinburgh when he arrived at Queen's University on the morning of the opening day. His Royal Highness attended the President's reception for students at which he presented cheques to Endeavour Essay prize-winners. With the President and General Officers he then attended a reception for overseas guests, which was followed by a civic lunch at the City Hall. His Royal Highness honoured the Council and the General Committee with his presence at their meetings in the afternoon and presented badges of office to the Presidents and Recorders of Sections.

The Inaugural Meeting was held in the evening of September 3 in the beautiful setting of the Sir Wm. Whitla Hall at Queen's University. The hall was unfortunately not big enough to accommodate all who wished to be present, and the proceedings were relayed to a large overflow audience at the Whitla Hall of the adjacent Methodist College, which was visited by H.R.H. the Duke of Edinburgh with the President, the Chancellor and other Principals. The Inaugural Meeting was preceded by a Graduation Ceremony at which the Chancellor of the Queen's University, Field Marshal the Viscount Alanbrooke, conferred the honorary degree of LL.D. on Professor A. V. Hill and Dr. D. W. Bronk, and the honorary degree of D.Sc. on Dr. E. D. Adrian, Sir Wm. Slater and Sir Richard Southwell. After the conferment of degrees, the President took the Chair and the Inaugural Meeting began with speeches of welcome by the Rt. Hon. J. H. Norritt, Lord Mayor of Belfast, and Dr. Eric Ashby, Vice-Chancellor of the University.

The President then delivered his Address on ' The Ethical Dilemma of Science ' (*Advancement of Science*, No. 34, p. 93), which was broadcast direct in the Home Service of the B.B.C. He was thanked by H.R.H. The Duke of Edinburgh, immediate Past President, who said :

' Before I try to thank the President for his most interesting and outstanding Address, I have a message to read from Her Majesty The Queen :

" I am very glad to send, through my husband, this message of good wishes to

the members of the British Association for the Advancement of Science. I well know that the strength of our country and Commonwealth depends more and more on the skilful application of scientific discoveries to the many problems that beset us to-day. With this in mind, I am happy to extend my Patronage to the British Association, whose meetings afford to scientists, old and young, such inestimable opportunities of freely exchanging their knowledge and their ideas."

'It seems to have been the general custom in the past for the Presidential Address to deal with some aspect of the work of scientists, especially when the President is a scientist. I certainly expected to hear from Professor Hill something about the work on muscles for which he is justly famous and which gained him a Nobel Prize thirty years ago. But this year, Mr. President, you have made a notable departure from custom. You have told us most ably and fearlessly what responsible scientists are thinking. You have stated their problems clearly and courageously and in your conclusions you have demonstrated that integrity of thought which is the hallmark of all great scientists.

'The Annual Conferences of the British Association have long served the twofold purpose of providing a meeting place for scientists to discuss their work as well as an opportunity for letting the layman know of the progress of Science. I am sure that your Address this evening will be welcomed by scientists throughout the world as sound common sense and wise counsel. To the layman and good citizen you have made clear the issues and responsibilities.

'Mr. President, you have told us about the strict principles which govern scientific thought and action, without which no progress of any value would be achieved. I believe that, in exactly the same way, Christian principles should govern the thoughts and actions of the community at large. In fact, the compelling duty of the good citizen is to apply these principles to all the problems of modern life whether they be personal, social, political or scientific.

'To-night we have been privileged to hear an Address which I have no doubt will go down in the annals of the British Association as one of the most important discourses made from the Chair in recent times.

'I hope it will prove to be controversial, for it is only by the clash of opinions that lasting judgments can be made. At least it has given prominence to a problem which has bothered many people both scientists and laymen for some time. Sir, we are all most grateful for what you have done for the cause of science this evening.

'You began, Sir, by telling us a little of the history of the previous meetings in Belfast. Let me anticipate the next occasion when the Association will enjoy the hospitality of this famous City, when I trust there will be present an ex-President with perhaps whiter hair, still taking snuff, in possession of all his faculties and still speaking with that clear voice and wisdom that we have all enjoyed so much to-night.'

During the following days the Sections received 287 communications on topics of current interest and importance in 74 sessions of which 10 were joint sessions of two or more Sections and one was a joint session between Section I (Physiology) and the Physiological Society. The Sections were accommodated in Queen's University, in the Methodist College, in the Municipal Museum and Art Gallery and in Stanmillis Training College. The Sectional Transactions are summarised at the end of this volume.

There were three evening discourses which were delivered in the Sir Wm. Whitla Hall. They were given by Mr. A. C. Hartley on 'Oil in Peace and War,' by Prof. A. Macbeath on 'A Plea for Heretics,' and by Sir William Slater on 'Science and an Expanding Agriculture.' On the afternoon of the second day of the meeting, Dr. D. W. Bronk, President of the American Association, delivered the biennial British-American Association Lecture.

During the week non-specialist lectures for young people were delivered in the Sir Wm. Whitla Hall. Five of these lectures were announced in advance and admission was controlled by tickets distributed to senior scholars in local schools, preference being given to those who became student members of the Association.

The lectures were ' Travel and Adventure on the Roof of the World,' by F. Kingdon Ward, ' Animals of the Past,' by Dr. W. E. Swinton, ' Noises Old and New,' by Prof. G. H. Bell, ' The Honey Bee,' by C. R. Ribbands, and ' Seeing is Believing,' by R. J. Bartlett. In addition, in order to provide more items of general interest and to relieve possible congestion in the Section rooms, the following kindly agreed to lecture at short notice : Professor J. K. Robertson (Power from the Atom), L. J. F. Brimble (Careers in Science), Dr. George Taylor (Plant Hunting in Tibet), Dr. Maurice Hill (Prospecting under the Ocean), Dr. Nazir Ahmad (The Textile Fibres of Pakistan) and Dr. D. W. Bronk. It is estimated that about 5,000 children heard one or more of these lectures.

Dinners were arranged by ten of the thirteen Sections including Section I, which held a joint dinner with the Physiological Society. The remaining three Sections were entertained at evening functions arranged in their honour. Section G (Engineering) were the guests of the Technical Instruction Sub-Committee of the Belfast Education Committee ; Section L were entertained by the Principal and Governors of the Royal Belfast Academical Institution and by the Association of Education Committees in Northern Ireland ; Section M (Agriculture) dined with the Ulster Farmers' Union.

Members of the Association were entertained at receptions by The Prime Minister and Government of Northern Ireland at Parliament Buildings at Stormont, by the Lord Mayor and Corporation at the City Hall, by the Belfast Harbour Commissioners at the Harbour Office, by the Chancellor and Senate at Queen's University and by the President and members of the Belfast Naturalists' Field Club.

The social functions also included two complimentary lunches, one by invitation of the Lord Mayor and Corporation in honour of H.R.H. The Duke of Edinburgh and one by invitation of the University for honorary graduates, officers and members of the Council and overseas guests. The Council and principal officers of the Sections entertained guests and principal local officers to dinner.

These and other arrangements, including the free use of Corporation transport, indicate the generous hospitality for which Ireland is famous. One national newspaper reported a criticism that there were too many social functions during the week of the meeting. British Association meetings, however, are unique in the opportunities they offer for free intermingling of men of science and non-specialists. Not only do the members need relaxation from the scientific proceedings but the social functions provide the best occasions for members to meet each other and for visitors to meet residents of the inviting City. In the same way excursions supplement the formal sessions by their scope for instruction and increasing the number of personal contacts made during the B.A. week. At Belfast there were 225 excursions and visits of which 150 were general and 75 were arranged by the Sections. They were admirably organised by local volunteers and covered a wide range of local industry as well as places of scientific and historic interest and scenic beauty in Ulster and Eire.

St. Anne's Cathedral was packed on the morning of Sunday, September 7, when members of the Association attended divine service. The lessons were read by the President and the Vice-Chancellor of the University and the sermon was preached by the Most Rev. J. A. F. Gregg, Archbishop of Armagh and Primate of All Ireland.

The proceedings of the meeting were well reported during the week in the press and by radio and subsequently by *Nature*, *Discovery*, and other periodicals. To mark the completion of a difficult task accomplished with credit the Local Executive Committee entertained press and radio correspondents to lunch on the final day. In a felicitous speech of appreciation, Dr. Eric Ashby, Chairman of the Committee, stressed the growing importance of good science reporting on which the Association so greatly depended in the work of presenting and interpreting science to the public who, as taxpayers, were the new patrons of science.

At their final session the General Committee passed with sincere enthusiasm a resolution of thanks to all in the region who had done so much to ensure the success of another great meeting.

A PLEA FOR HERETICS[1]

by

PROF. A. MACBEATH

IN the year 1644—two years after Galileo died—when England was a small and poor country, without overseas possessions and with her people divided by civil war, the Government of the day, in the interests as they believed of safeguarding the liberties for which they were fighting, introduced a measure to curtail freedom of publication. This measure called forth from John Milton, the poet, one of the most remarkable pleas ever made for tolerance to heretics and nonconformists. In the course of his plea, with what might seem a strange disregard of their untoward external circumstances, Milton predicted the future greatness of the English people. In support of this prediction he submitted only one piece of evidence. 'They are,' he says, 'a nation so pliant and so prone to seek after knowledge'; they 'eagerly pursue the truth'; they 'prize the liberty to know, to utter, and to argue . . . above all liberties.' Therefore, he argues, they are 'destined to become great and honourable in these later ages.'

For three centuries the English-speaking peoples have continued to prize and, with occasional lapses, to practise this freedom, which Milton with the sure insight of the poet recognised to be the foundation of all other liberties, and the record of their achievements has gone far to verify his vision of their destiny. By the beginning of the present century this freedom, which is an essential condition of the science which this Association exists to advance, seemed so thoroughly established that people tended to take it for granted as part of the natural order of things; but to-day it is threatened from so many quarters that it is perhaps in greater danger than at any time since Milton wrote. Wherever we look—East or West or South—we see symptoms of a reaction against it which some people regard as merely a temporary aftermath of the storms through which mankind has recently been passing, but in which others fear they hear the first rumbles of a coming avalanche which, unless steps are taken to avert it, may engulf the spirit of free enquiry in a disaster from which it may take mankind another thousand years to rescue it. Indeed some people are beginning to wonder whether the conditions necessary for the spirit of free enquiry to flourish, instead of being a natural state of affairs to be taken for granted as normal, may not be the result of an unusual set of circumstances which occur only on rare occasions and at remote intervals in the history of mankind. And before we reject this view as a pessimist's nightmare, we would do well to remember that so far as we can discover such favourable circumstances have occurred only twice in the history of our race—once for some centuries in Greece and the other since the sixteenth century.

But whatever we say to these large and perhaps dubious generalisations there is no doubt that the present century has witnessed a serious decline in respect for freedom of all kinds, and that so widespread a phenomenon must have causes which are pretty deep-seated in our form of civilisation. It is not necessary to dwell on what we saw in Germany and Italy or what is taking place on the other side of the Iron Curtain; for it may be said that none of these countries enjoyed the long tradition of freedom of the English-speaking peoples, and that though such things could happen among them they could not happen here. But before we accept so easy and comfortable a view, let us look at some of the symptoms of similar tendencies among the English-speaking peoples themselves. I want first to refer to the symptoms in

[1] Evening discourse delivered at Belfast on September 7, 1952, during the Annual Meeting of the British Association.

America—for several reasons. (1) The United States share all our traditions, and their achievements in the cause of freedom have been very great. Their early fathers left these islands as heretics against the dominant religion of their day; and when the interests of freedom seemed to demand it the founders of the Republic did not hesitate to rebel even against constitutional authority. They have always been the champions of the persecuted in every land and they have provided an asylum to refugees from tyranny and oppression of every kind. (2) We can view what is happening in another country with greater detachment than what is taking place among ourselves. If we could see others as they see themselves we would have a better chance of seeing ourselves as we are. And (3) the hesitation which I must confess I at first felt to refer to conditions in the United States and the objections which are likely to be raised against my so doing, I realised on reflection to be themselves clear evidence of the totalitarian tendencies which I want to illustrate. That dissent should be regarded as disloyalty, criticism as an unfriendly act, difference of opinion as disaffection, show how far we have drifted in the direction of authoritarianism and away from the democratic principles which we profess—principles according to which free and frank and critical discussion of all questions should be not only tolerated but encouraged.

Here then is the considered opinion of two of the most sober and serious-minded American scholars about the tendencies which they see at work in their country. Professor Boas of John Hopkins University, writing in the May number of the *John Hopkins Magazine*, says: 'I am not given to cries of alarm . . . we have developed a civilisation which every student of history knows to be unique. We are strong in material wealth, in inventiveness and in national solidarity. . . . But one sees on all sides a creeping paralysis which has begun to infect our schools, our government and the general public itself. The first symptom of that disease is the return of authoritarianism.' And after reviewing in detail the symptoms of this disease in almost every aspect of life—the Press, the radio, the schools, the government and even the universities—he concludes: 'If one thinks about these things, the trends which they exemplify, the state of mind which prompts them, one cannot deny that the philosophy of authoritarianism is abroad in the land.' And Professor Commager of Columbia, in the first of a series of six lectures by eminent scholars 'to vindicate the claims of criticism and dissent and nonconformity' declares: 'The responsibility of vindicating the claims of freedom confronts us now in urgent fashion. . . . We are witnessing to-day a broad official and non-official attack upon nonconformity . . . the development in this country of the kind of society in which freedom of enquiry does not flourish, in which criticism does not flourish, in which originality does not flourish. This is no alarmist bugaboo: it is a development already under way.' I should add that these men are second to none in their concern for the security of their country but they contend that the sense of insecurity engendered by fear, suspicion and secrecy is already retarding, and if continued may destroy, the very national security which the authoritarian tendencies are intended to promote. If these things happen in the green tree what may we expect in the dry?

It should, however, be noted that the context of the statements which I have quoted makes at least one thing unmistakably clear: the friends of freedom in America are alert and active.

But we needn't go to America for symptoms of authoritarian tendencies. For evidence that they exist among ourselves, we need go no further than the sober statement of your President in his opening address. He told us that when your Association first met in this city his predecessor could counsel his fellow scientists to 'continue in the undisturbed enjoyment of their own pursuits untroubled by the excitements and distractions' of the practical world around them: but, he continues, 'the practical importance of science to-day and its impact on public affairs have greatly reduced that undisturbed enjoyment.' He was mainly concerned with the fresh problems and difficulties which the impact of science on society has brought in its train and the dilemmas which they present to mankind

in general and scientists in particular. But serious as these are there may be a more serious danger still. It is that certain tendencies in the society which science has helped to produce may slowly but surely destroy the spirit of free enquiry and produce a state of affairs in which science can no longer flourish. Science began its triumphant career and continued to flourish within the framework of a particular way of life, and we are apt to take that framework for granted and to forget how much it may have been responsible for producing the qualities of mind which made the great scientists. But the applications of science have modified and are modifying that way of life. It is with the possible impact of this modified society on science that I want primarily to deal ; and I shall be concerned with the impact of science on society only as far as is necessary to make clear the tendencies in our society which are in danger of destroying the conditions of the possibility of science.

Before considering these tendencies, the causes which produced them and the consequences which are likely to follow if they are allowed to operate unchecked, I want, in order to avoid misunderstanding, to make some preliminary observations. (1) I see no evidence which suggests that the moral or intellectual qualities of our people have deteriorated, but the present generation has to bear heavier moral and intellectual burdens : the conditions in which we live make greater demands on the intelligence, the imagination and the sympathy of our people, and as a result they are bewildered and perplexed and unhappy. (2) To blame science for this state of affairs is merely to darken counsel. Though science has helped to produce it, it is not an inevitable consequence of science or even of its application, if we consider these in isolation. Science, however, didn't develop in a vacuum, but in the context of a society which provided its stimulus and inspiration and which produced the men who engaged in it. There is no going back to the medieval synthesis which science has helped to disintegrate, though there were factors in that synthesis which we have let go too uncritically and too completely, and we must regain and retain our hold on them if we are to use wisely the power which science has placed at our disposal. (3) This state of affairs is not due merely or even mainly to the wilfulness or wickedness of any man or group of men. It is inherent in the nature of our society and there is no escape from it except to recognise the situation frankly and try to control it consciously. (4) We cannot solve our problems in isolation : by neglecting half of life because we find it difficult to reconcile it with the other half. We need security and social cohesion, order and discipline, but we also need freedom and initiative, originality and the spirit of adventure. And finally some of the principles which I wish to emphasise—principles the neglect of which seems to be the source of many of our difficulties and frustrations—are in the peculiar position that we assent to them in principle but neglect them in practice. We pay lip-service to them and then ignore them. We inoculate ourselves against taking them seriously by calling them platitudes or by saying that they are all right in theory but won't work in practice. Let me give one or two examples. We accept the principle that the end does not justify the means, and yet we say that we must use totalitarian methods to combat totalitarianism. We say that earning a living is a means to life, and yet we are in danger of destroying or at least marring the quality of the life by the way in which we earn a living. Your President lays it down as one of the conditions of scientific progress that every scientist should endeavour impartially not only to find the truth for himself but also communicate it to others. ' What then,' he asks, ' of the abolition of secrecy ? ' He answers : ' In principle, yes ' (and for this he gives the best of grounds) '. . . but in the practical world of to-day . . . (it) . . . is out of the question '—at least without very considerable reservations. This denial in practice of principles to which we assent in theory is what we call being realistic. But the discrepancy between our profession and our practice is the source of much of the frustration and malaise in modern life ; for to accept discrepancy is, as Whitehead warns us, destructive of candour and moral cleanliness. I am old-fashioned enough to believe that nothing

can be true in theory which doesn't work in practice, that if a principle is sound the proper way of treating it is to act on it, and that to revitalise our society we must take more seriously the so-called 'platitudes' to which we assent but which we don't believe. We must reformulate them and embody them in our institutions and way of life in such a manner that they will be true in theory and apply in practice. Only then will we grasp their significance either in principle or in practice, and only then will our life be coherent and we at one with ourselves.

What then are the factors in our contemporary society which are in danger of crushing freedom of enquiry and what causes produced them? The two most characteristic movements of the modern age are science and democracy. They spring from a common root—respect for the dignity of man as an intelligent being—and they have two common features. First, they both stand for what Plato called the victory of persuasion over force, of discussion over dictation. The appeal of science is not to brute force but to evidence which will satisfy the intelligence, and the evidence to which it appeals is there for all who have the capacity and take the trouble to see. Secondly, they are both tentative and experimental. They reject all claims to dogmatic authority or certainty. According to the democratic attitude man should not submit to any control which he has not himself created and cannot modify to suit his purposes; and the scientist regards every conclusion at which he arrives as provisional, a step towards not the attainment of final truth. The way to truth he regards as long and difficult, to be reached only by partial approximation and not at one leap. No doubt there have been times when the conclusions, presuppositions and categories of science have been in danger of hardening into dogmas, but in the main this was the work not of the great scientists but of small scientists and their camp followers; and it was a betrayal of the spirit of science.

For three centuries men have placed their faith in this new attitude which finds expression in science and democracy and they have been trying to embody it in institutions and a way of life; but in the moment of its triumph its fruits seemed to turn to ashes in their mouths; and during the present century the presuppositions of both science and democracy have been challenged and they are called on to defend themselves. The reasons for this, however, are not to be found in either science or democracy but in the two other characteristic features of the modern age which followed the applications of scientific knowledge—technology and industrialism. It is they, I think, which have produced the state of affairs which is in danger of destroying the scientific spirit to which they owe their origin. The results of pure science are wholly good. Not only are the knowledge and understanding of natural processes to which it leads a source of deep intellectual satisfaction, but the discipline, the humility before fact, the truthfulness which ignores no inconvenient factors, the calm confidence which follows the evidence exert an important moral influence on those who practise them. But we should not distinguish too sharply between pure and applied science or between the parts which intellectual curiosity and practical interest in the well-being of mankind played in the development of modern science. The modern age opened with a new attitude to knowledge, an attitude which regards it not, or at least not merely, as something to be contemplated and enjoyed but as power to be used for the welfare of men. And it is to the power over his environment which it placed at man's disposal that science mainly owes its prestige in the modern world. For modern man is as credulous, as much impressed by miracles, as his predecessors; and the miracles of the modern world—motor cars and aeroplanes, wireless and television—all belong to science; and it is they which for the mass of mankind constitute its justification. It was on them and their value to mankind that men placed their faith during the nineteenth century. The powers which they placed at man's disposal were undoubtedly great. If they were used wisely and if steps were taken to prevent a disproportionate increase in population, they could free the mass of mankind from the grinding poverty and the degrading drudgery which in previous ages had been the lot

of most of them, as well as add much to the amenities and graciousness of living. But the dangers and discomforts which they brought in their train have been equally great—high explosives and atom bombs, the discomfort and squalor of urbanisation and the exploitation of man by man ; and it is of these that men have been increasingly conscious during the twentieth century. The fact is that the knowledge which science brings and the power which its application gives to man are morally neutral. They can be used either for good or for evil, and when men found by bitter experience that they were not always used wisely they reacted not only against freedom to misuse them but against freedom in general.

This reaction is in part at least the result of a twofold confusion. First, there is a confusion between science and the results of its application, and a consequent failure to distinguish between the freedom which is a necessary condition of scientific discovery and progress and the control which has to be exercised over the use which is to be made of the results of applied science if they are to contribute to the welfare and not to the undoing of man. Those who wanted to use the products of scientific techniques demanded for themselves the same freedom as science rightly claimed, and at first the claim was granted ; and when men discovered the results of the indiscriminate use of such freedom in unhygienic factories, unregulated growth of towns and the exploitation of man by his fellows they reacted against freedom as such. Secondly, there is the confusion between what science does and what it does not profess to do. Men had expected too much of science—not only knowledge and power but the wisdom to use it aright. But science cannot supply us with ideals in the light of which we can direct our efforts. For it is concerned with facts not with values ; and so it cannot justify anything—even its own activity, still less the purposes for which the power which it supplies is used. This is true not only of the physical and biological but also of the social sciences which this Association has taken under its ample wing. These sciences can explain how a state of affairs came to be as it is but not whether it is good that it should be so. The reasons which they give are reasons which explain, not reasons which justify. It is true that some attempts have been made to explain values according to the principles of natural science. Such explanations tend to regard values as subjective and ideals as the projection of our desires. According to them one desired object is as good as another—' pushpin as good as poetry '—if anyone desires it with sufficient intensity, as Bentham puts it. But if this is the only account which can be given of value, nothing can be justified—not even science itself. According to it I can explain, e.g., my loyalty to a particular school by the fact that I once attended it, but I cannot justify my loyalty to it because I cannot decide whether it is an object worthy of my devotion. Justification is in terms of ends not origins, purposes not natural causes, ideals not antecedent conditions. I am putting the issue sharply because it is quite simple, and there is no point in evading it. Either values are merely relics of a pre-scientific age and, though we can explain things, we cannot justify anything, or else science cannot give a complete account of them. Science can explain why I entertain an ideal but not whether the ideal is worth entertaining. This does not mean that ideals and values are not capable of being logically supported and rationally defended : it only means that there are legitimate objects of intellectual curiosity which are not amenable to the methods of science. If we are to conceive or achieve a coherent and desirable way of life we must take account of both facts and values. We cannot reduce one to the other or dispense with either. Our most difficult problems are concerned with matters in which both are involved and our chief difficulties to-day seem to arise from discrepancies in our values rather than from ignorance of facts.

To the results of these two confusions has to be added a natural resistance on the part of the ordinary man to the scientific attitude. The ordinary man desires certainty and mental security. He is interested in answers to questions rather than in evidence and argument. And there is much in his environment which leads him to expect that there exists somewhere a body of fixed and certain

truth to be accepted as final. It requires a long training and a hard discipline to eradicate this expectation and to accept the scientific viewpoint according to which all conclusions are on trial and the function of the mind is to be for ever reaching out, for ever learning and testing. Even scientists generally adopt this attitude only within the limited field of their own science. Outside that field they are liable to be as uncritical and dogmatic as other people.

And there is yet another sense in which the scientific attitude is opposed to some of the settled tendencies of human nature. As we have been repeatedly told during the last few days science is by its nature universal and international. It involves the co-operation of men of different classes and countries—a co-operation which proceeds through publication. But the dispositions, the emotional attitudes, the sympathies of men tend to be narrow and provincial. Many of our traditional, emotional and social habits, and the institutions and forms of social organisation in which they are embodied, were developed in and fitted for relatively small groups like peasant communities or city states, and they change very slowly. Now this introduces a discrepancy, a sense of tension, between our intellectual and our valuational interests and tends to be an obstacle to the free universal co-operation which is essential to scientific progress.

This resistance which our habits and expectations, natural and induced, offer to the scientific attitude has been greatly intensified by the changes which scientific techniques have introduced into the modern world. On the one hand the development of quicker means of communication and transport has brought men of different nations and races into more intimate contact and increased their mutual dependence. On the other the units of economic and industrial organisation required to make the most effective use of the techniques produced by science have been growing in scale and complexity. As a result the individual man to whom science and democracy promised a greater mastery and control over his environment finds himself not only dependent but powerless ; and it is difficult for him to feel that his life or his work is significant. If he is to do anything—even to survive—he must join with others, often on conditions which are not of his choosing ; and even when he does join with others all that they may be able to do is to send a deputation to wait on others who are often remote but in whose hands ultimate power rests.

In such large scale organisations—industrial and political—few men, fewer than ever before, have the opportunity to exercise initiative, to make responsible decisions, to guide and control much even of their own behaviour. Planning on a large scale, involving the control of men, becomes essential ; for the experience of the nineteenth century showed that, unless we understand and take steps to control the results of technology, they will control us with results which no one willed and which few desire. But planning while necessary has its dangers ; the planner, and especially the administrator of the plan, is apt to be the foe of freedom. He is in danger of ignoring the distinction between persons and things, and the larger the scale of the organisation the greater the danger. Things we rightly master and control and use ; their value consists in ministering to our purposes. But persons are subjects of purposes, not just objects of the purposes of other people. They are independent, responsible, self-governing individuals. But it is easier to make a pattern with dead wood than with live shoots. The legislator, the organiser, the administrator whether industrial or political is apt to forget that all plans and all forms of organisation are means not ends in themselves ; that every plan has its price and that the price may be too high ; and that some sacrifice of neatness in the plan may be necessary to realise the end of all planning—the provision of conditions in which human beings can exercise their powers, develop their capacities and live full and responsible lives. One of the main problems of our time is to guard against the possible tyranny of administrators—a tyranny which is different from but not less real than the tyranny of priests and kings with which our fathers had to contend. I am not blaming the administrators. They have a necessary function to perform and many of them are doing their best, but

the power which they wield has peculiar dangers for themselves and others. I once took a small boy to get a pair of shoes. When he tried on one pair he complained that they hurt his toes, but the salesman protested that they couldn't hurt him, that they were a perfect fit and that what the boy needed was a good thrashing. Now administrators are apt to be like that. They love conformists, people who take what they are given and do as they are told. But freedom lives and grows only by exercise. Of course the administrator will say that he objects only to irresponsible and ignorant criticism, that if people were not so fussy and stubborn and unreasonable they would accept his plan, that he allows all reasonable liberty, all that is consistent with the good of the community. But that has been the stock argument of tyrants and dictators, especially benevolent dictators, all down the ages. They identify the plan which they wish to impose with the good of the community, and then all dissent is regarded as disloyalty, all criticism as unreasonable, all objectors as traitors; and then the only safeguard against major mistakes is gone.

And there is another major difficulty. Even if a plan is good and its administration wise, it takes time and patience and experiment to embody it in institutions and operative ideals and to adjust our habits of thinking and feeling to it. But the pace of invention is always quickening and the changes which it produces are coming with such rapidity that there is not sufficient time to make the necessary adjustments to them. This rapidity of change is perhaps the most characteristic feature of recent times and it makes adaptability and initiative more necessary and yet more difficult than at any previous period. In earlier times the experience of past generations and the traditions and institutions in which they had been embodied—the fruits of many generations of experience and experiment—were handed on from one generation to another to guide the fallible judgment and the faltering footsteps of the inexperienced and to act as a constant reminder to them of the way in which they should go. To-day, owing to the rapidity of the changes which are taking place, the experience of parents is liable to be a hindrance rather than a help to their children. This is why flexibility, open-mindedness, responsiveness to new ideas are more necessary than ever before. The man of fixed ideas and habits is to-day a public danger. This does not mean that tradition—the accumulated wisdom of the past—has no value or that we don't need principles to guide us; but the tradition should not be accepted uncritically: it must be rethought by each generation and modified to suit the new conditions; and the principles should be embodied in habits and institutions which are appropriate to the changing circumstances. But at best there is always a time-lag between technological changes and our habits and institutions, and this causes a sense of tension and frustration in our society.

When we look back on the nineteenth century we find it easy to blame our forefathers for the moral insensitiveness which allowed child labour, unhygienic factories, the growth of slums and other evils. They did so in part at least because they were applying the mental habits of the eighteenth century to the new problems of the nineteenth. But are we in any position to criticise them? Isn't there the same time-lag to-day? To take just one example out of many that could be quoted: in one week last year the casualties on our roads amounted to more than 6,000 and in the whole year they equalled the casualties of a major war. I believe our successors of fifty or one hundred years hence will regard our complacency about this state of affairs and our failure to deal effectively with it as one of the most extraordinary examples of moral insensitiveness in the history of our race.

The result of these tensions, disharmonies and incoherences in our way of life is a sense of frustration and futility and unhappiness. E.g. the scientist feels frustrated because of the use which is made of the results of his discoveries, the failure to deal with their unforeseen consequences, the secrecy which interferes with his work. The ordinary man feels frustrated because of the contradiction between the mastery and control promised by science and democracy and his

individual helplessness, between his emotional and social provincialism and the universality of science and industrial organisation, between the ends which he seeks, security and happiness, and the means which are necessary to realise them, conditions of life which do not call forth or even leave room for the exercise of his full powers, and so on. Thus modern man in the society which science has helped to create is discontented and unhappy. For the major cause of unhappiness is dividedness of mind, conflict of loyalties, discrepancies in the way of life. Mind is an effort after unity and coherence. Its life is a whole and to divide it or introduce contradictions into it is to destroy its peace—even to impair its intellectual integrity. But there is little unity and cohesion in the life of twentieth-century man. His different interests conflict, his allegiance is divided, he is not at peace with himself or his environment. He is, therefore, unsure of himself, uneasy and afraid. Of this state of affairs the tendency towards authoritarianism, the revolt against reason, the distrust of the intelligence, are symptoms. For these are symptoms of fear, unconscious fear. They are attempts to get external quiet where there is no inner peace, to cover up the skeleton in the cupboard. It is true that within each science there is a sphere of order and rationality ; but such limited and short-term rationality as there is, is mainly concerned with means, and as regards ultimate issues the twentieth century has been characterised as much by irrationality in theory as it has been by unreason in practice. Now the heretic, the nonconformist, the man who demands reasons, is uncomfortable about this state of affairs and he makes other people uncomfortable too ; and those who prefer ease to liberty are apt to regard him as revolutionary, a disturber of the peace, a man who turns the world upside down, and to turn on him with impatience and resentment ; and even if they do not impose positive restraints on him he finds it difficult to breathe in the atmosphere of their society.

What, then, is to be said on behalf of the critic, the dissenter, the man who fearlessly seeks and speaks the truth? What function does he fulfil? Why is it desirable not only to tolerate but to encourage him? Toleration is to be encouraged not as an indulgence to error, but as a method of arriving at truth and as a safeguard against mistakes. It is interesting to note that our fathers applied this principle in many spheres and found it to work. E.g. in our parliamentary form of government, we have a government and an opposition ; in our legal system, we have a counsel for the prosecution and a counsel for the defence, and so on. In authoritarian systems, on the other hand, we get one-party government, and if there is a counsel for the defence in people's courts, it is doubtful if he has much part to play. It is true that not all heretics and nonconformists are men of insight and vision, and that they are not always mindful that they have duties as well as rights. But even if ninety-nine of them be fools, or worse, it is worth while putting up with them for the sake of the hundredth.

And what is the alternative to tolerance for the heretic? It is to silence or suppress him. This can be done effectively enough by putting him in a den of lions or a concentration camp or a gas chamber, but even that may not destroy his ideas ; and if it does, the result is stagnation. Short of that the only effective way of dealing with him is not to denounce him as wicked but to persuade him that he is wrong, not to silence but to answer him ; and if we cannot answer him, because there is no answer to give, to accept his criticism even if it hurts, as truth often does. Failure in tolerance is evidence of an ultimate lack of faith in the soundness of our beliefs, in the value of our way of life and in the intelligence of our people, evidence of fear that they cannot withstand criticism. Moreover, intolerance of criticism shows, on the part of those who practise it, an arrogant claim that they could not conceivably be mistaken. They seem to forget that those who first promulgated the ideas and ideals to which they to-day demand conformity, and indeed all who made permanent contributions to the welfare of mankind, whether in science or religion or social and political organisation, were all in their day innovators, critics, nonconformists, heretics ; and that to-day's heretics may be their real followers, while those who turn their

doctrines into dogmas and seek to impose them by totalitarian methods betray their spirit.

The function of the heretic and critic, then, is to force us to keep examining and testing, revising and perfecting our beliefs and ideals. His attitude is the attitude of science whose conclusions are always on trial. And this is the only sure safeguard against error and degeneration. It has performed an indispensable part in the slow progress of mankind towards civilisation ; and the day it is no longer allowed to perform that function stagnation will set in, and freedom and science and all they stand for will decay and die, and the sweetness and cleansing efficacy which they impart to our way of life will disappear as silently but as surely as the fragrance escapes from a faded flower.

To sum up, the position as I see it is this. In the last analysis, there are only two ways of dealing with human beings—the way of persuasion and the way of force. Every society has to make some use of both, but the resort to force is always a confession of failure, and when it enters the mental and spiritual sphere, the realm of beliefs and ideals, the result is intellectual and moral disaster. Science stands for the way of persuasion. It appeals to the intelligence, to evidence and argument. It can only flourish in an atmosphere of freedom, an atmosphere in which dissent and nonconformity and difference of opinion are tolerated. And freedom, like peace, is one and indivisible. If it is threatened anywhere, it is everywhere in danger. But in our society which science has helped to produce and which it is continually modifying, there are factors and tendencies, some of which I have tried to describe, which make it difficult for the critic and the independent thinker to flourish. When we hear a statesman say that no man has a right to be wrong, when we pay those who rely on the method of force the compliment of imitating them as we do when we say that we cannot combat totalitarianism except by totalitarian methods, when in the professed interests of security we are in danger of destroying the way of life which we want to protect and thereby of undermining the national security which we wish to safeguard, freedom and science are in danger and it behoves their friends to gird on their armour. The way of persuasion is hard and long but it is the only way of hope for a tortured and perplexed humanity ; for we cannot bring about a desirable state of affairs by means which are inconsistent with the end which we pursue.

If this diagnosis of our contemporary situation is even approximately correct, scientists cannot be indifferent to the tendencies at work in our society, for they concern them vitally. They can no longer afford to say, as some of them are at times inclined to say, to their colleagues who call public attention to totalitarian tendencies: ' Leave us alone to get on with our work ; don't criticise or disturb our paymasters.' That is the easy but, if I may say so, the selfish way. It evades the issue and if long continued it may prove disastrous to science. For perhaps the chief danger to science is not so much from positive restrictions consciously imposed as that the atmosphere of a society which rewards conformity and penalises dissent may cease to produce scientists, men imbued with the spirit of free enquiry.

It is not for me to tell those whose duty it is, in the words of your President, not only to engage in the practice of science but to hand on its traditions unimpaired to their successors, what they should do about this situation. All I say is : the danger that the spirit of science may be crushed by its own creations is real, and in the face of it scientists cannot afford to remain silent and inactive.

BIOLOGICALLY SIGNIFICANT MACROMOLECULES[1]

by

PROF. M. STACEY, F.R.S., AND OTHERS

THE aim of this discussion was to survey knowledge of the chemical and physical properties of some of the 'macro' or giant molecules which are important constituents of animal, plant and bacterial cells. The building up and breaking down of these molecules are intimately concerned with the processes of growth and the build-up and breakdown processes are controlled in a remarkable way by 'enzymes' which have a biocatalytic action. In the human body the formation of the giant molecules is worked to a precise pattern and their size and shape must be repeated exactly in any growth process or conditions we know as disease will occur. Some of the giant molecules are, for example, the lubricating fluids for the moving parts of the body Others are natural plastics which have a remarkable elasticity. If they are not to the correct standard then rheumatic conditions occur and movement is painful or impossible. When the precise chemical architecture of some of the body's constituents is known, a substitute substance may be made and used medically. In blood transfusion, for example, great losses of liquid may have to be made up very rapidly. It is not sufficient to infuse water or salt because dilution of the viscous plasma proteins is harmful. Successful substitutes have been made having the right kind of properties which imitate those of plasma proteins but which are made entirely out of sugars.

Professor Maurice Stacey described how researches on the complex carbohydrates present in disease-producing bacteria has given a picture of their size and of their shape and has shown how similar they are in some respects to carbohydrates present in body constituents such as blood, joint fluids, skin, gastric secretions, and so on.

Complex carbohydrates (polysaccharides) have been shown to be the main constituents of some vaccines such as the T.A.B.C. vaccines which are so completely effective in the prophylactic treatment of typhoid, cholera, etc. It has been shown in America that polysaccharides, which cover the surface of those germs which cause pneumonia, can be used in minute amounts to give a vaccine which will completely prevent the disease. Knowledge of chemical structure in this field is giving a most important insight into certain skin diseases.

Allergic disorders are now being traced to surprisingly small divergencies from the normal in some of the chemical 'bricks' which go to make the giant protein and carbohydrate molecules.

The important fact has been discovered that the bacillus which causes tuberculosis has at least seven distinct kinds of polysaccharides in its make-up, and efforts are being made to discover whether any of these might have an immunising effect against this baffling disease.

When the giant size of the polysaccharide molecules is reduced they are rendered quite harmless in the body and do not have an immunising or sensitising effect. This fact has been made use of in the development, mainly at Birmingham University, of the substance dextran, which is perhaps the best possible blood plasma substitute we now have and certainly the best artificial remedy we have against burns and shock. A harmless microbe, Leuconostoc, turns table sugar into a viscous sticky polysaccharide.

By the aid of acids, by heat or by the action of supersonic sound waves, the polysaccharide is broken down and 'tailor

[1] Popular summary of a session in the Chemistry Section at Belfast on September 9, 1952.

made ' fractions are picked out so that they are completely compatible with blood itself. The material is not intended to replace the blood plasma, now so valuable, but it is to extend it, and the ideal treatment for blood loss, shock and burns is to use the two in conjunction.

The development of dextran in Britain has been described by Lord Hankey as a shining example of happy co-operation between a University department, Government departments (the Medical Research Council and the Colonial Products Council) and industry. The small firm Dextran Ltd., of Darlington, staffed by Birmingham scientists has now been taken over by Glaxo Laboratories Ltd., in order to maintain correct distribution of the material.

Another product of dextran—this time of even smaller molecular size, has been combined with sulphuric acid in order to give an important new medicinal which prevents blood from clotting and which is therefore important in thrombosis studies and in operations.

In studies on rheumatism the body tissues are yielding up their secrets. We already know a great deal about the composition of joint fluids, cartilage, sinews, tendons, skin, etc. They all contain complex sugars, many of them being in the class of the nitrogen-containing sugars and others the so-called oxidised sugars.

Size and shape determine fluidity, lubricating properties, elasticity. These in turn may be under the control of cortisone or the adrenocorticotropic hormone (A.C.T.H.) so that future studies will be of great interest.

In the complex systems of the body, growth of giant molecules of diverse nature goes on side by side. One may influence the other, and this gives us a new line of research. It has been shown in America that one bacterial polysaccharide will cause retrogression of certain types of tumour, and a limited success in the cure of some types of tumour has already been achieved. There is a good deal of evidence coming forward that the growth of viruses can at least be slowed down and sometimes prevented by the presence of certain mould and bacterial polysaccharides. This is a new approach to the study of virus diseases and the ' elbowing out ' of a growing harmful giant molecule by a harmless one may well repay study.

Dr. B. E. Conway's work at the Cancer Hospital in London described another approach to the problem of cell growth. This involves a study of the giant thread-like molecules which occur in the nuclei of all living cells. These again are carbohydrate containing and are known as the deoxypentose nucleic acids. They can be isolated in the form of fibres and in salt solution give a highly viscous solution. When the thick solutions are treated with X-rays or with ' nitrogen-mustard ' gas they gradually become more fluid as the giant molecules break. A method of measuring at least one effect of X-rays and of mustard gas is thereby obtained. Both X-rays and certain mustard gases destroy cancer cells in a specific way so that a new approach to cancer is being developed.

Since model substances are often valuable as tools for research, starch has been chosen for study of the building up and breaking down of a big molecule under standard conditions.

Dr. G. A. Gilbert explained how starch has been shown to be a mixture of amylose, a long chain-like molecule, and amylopectin, a highly branched molecule having jelly-like properties. Both of these substances have now been obtained in the Birmingham laboratories from a variety of plants such as the potato. Most plants contain a mixture of each though plants are known which contain one kind only.

It is not generally known to the public that both components of starch can be synthesised in the test tube. A suitably prepared enzyme (the *P*-enzyme) extracted from potatoes, will act upon a synthetic sugar derivative glucose phosphate and turn it into the giant long-chain molecule amylose. This gives a deep blue stain with iodine. A second enzyme (*Q*-enzyme) will seize on the amylose and tie it into knots giving amylopectin which gives a red stain with iodine. Both enzymes appear to need a few molecules of starch to trigger their action.

It is thus clear that a profound and complex biological system is largely under scientific control.

SCIENCE AND AN EXPANDING AGRICULTURE[1]

by

SIR WILLIAM SLATER

IN order that he may live man requires food and clothing; for these he depends on the plants and other animals around him.

Primitive man, living in small family groups, met his simple needs by collecting fruits, seeds, roots and other edible parts of plants and by killing wild animals for their flesh and skins in the immediate neighbourhood of the cave where he lived. As human communities grew in size, the surrounding wild life no longer supported them and they had to collect and hunt further and further afield. When the distance over which food had to be gathered and carried back to the headquarters of the tribe became too great, the community was faced with two alternatives; it could either become nomadic and move on from one hunting ground to another as the supplies were exhausted, or cultivate plants and domesticate animals in order to obtain more food and clothing from the land around a permanent village.

Some nomadic tribes, not wishing to rely entirely on hunting, domesticated animals and grazed them on the native pasture, driving them to new areas whenever the supply of animal food was exhausted.

This pattern of expanding agriculture has been continuously repeated throughout the history of civilisation. When the growth of a people has overtaken the supply of food and raw materials from the available land, they have either sought new land to exploit or by better farming produced more from that which they already had.

In England the earliest village communities based on the Saxon manor were self-supporting, the transport of heavy goods from one part of the country to another being almost impossible. Each village produced all the community needed; hence the agriculture was diversified and there was no specialisation in any crop or type of stock to which the soil and climate happened to be particularly suited.

As travel became more common in the fourteenth century, the wealthier people began to want luxuries from the Continent. To buy these goods wool and woollen textiles produced from sheep grazing the English downlands were sent in exchange. So specialised farming began and the system of exchanging the products of one type of farming for those of another was introduced. This trade greatly strengthened and enriched the life of the static farming communities.

The growing demand for produce to exchange for luxuries from abroad and for more food for increasing population at home could, however, not be met by a simple type of specialised agriculture alone; to do so it was necessary to bring more land, previously accepted as waste, into cultivation, by clearing scrub and by simple drainage schemes.

By the seventeenth century the then known methods of expanding the production of food and raw materials were no longer sufficient to meet the demand and science for the first time came to the aid of agriculture, by showing how more waste land could be brought into use and how the output of the existing farms could be further increased.

An engineer, Sir Cornelius Vermuyden, undertook the drainage of the fens to turn an area of nearly 700,000 acres of bog, pools and reed-shoals into richly fertile land. From 1626 to 1652, throughout the period of the Civil War, he worked with the financial backing and encouragement of the Earls of Bedford until in the latter year he was able to report: 'wheat and other grains, besides innumerable

[1] Text of an Evening Discourse delivered on September 8, during the Annual Meeting in Belfast.

quantities of sheep, cattle and other stock were raised, where never had been any before.'

Those great founders of modern agriculture—Tull, Townsend and Coke—were not only landowners and farmers, they were also the pioneers in agronomy and agricultural botany. Tull at work on the selection of sainfoin seed by observation and experiment, or testing different depths, spacings and rates of sowing, has his counterpart doing similar work in many a research station today. Townsend, trying out his turnips and grass mixtures in new rotations and studying the interaction of stock and crop, was as good a scientist as any amongst us. Coke carried on his work showing the value of claying on light land, of ground bones as a fertiliser, of dung in increasing fertility and of the selection of the right grasses for sowing down a pasture. He was also a great teacher ; whether he was instructing the village children in botany in order that they might gather the grass seed he wanted for his experiments, or encouraging his tenants and neighbours, at the famous Holkham sheep shearings, to follow the new methods he had found to be successful, he always had the scientific advancement of agriculture in mind.

These men and their contemporaries showed us how to farm for high yields by using suitable crop rotations and by bringing stock on to the arable land.

Animal breeding as practised by Bakewell may have been more an art than a science, but we must acknowledge that it is still very much an art today. In spite of our modern genetical knowledge, we are now only on the threshold of scientific animal breeding and are still following much the same methods as those used by Bakewell. Whether Bakewell and the other early breeders were scientists or artists is of little consequence, the value of their work lay in showing the importance of close observation and the need in breeding for systematic selection towards a desired type. By these methods they produced the improved stock needed to take full advantage of the heavier crops being grown under the new mixed farming systems.

The first slow development of scientific farming from Vermuyden's drainage of the fens to the perfection of Bakewell's Leicester sheep occupied more than 150 years, yet at the end of that time many farmers were still following the traditional ways of the seventeenth century ; only a few were applying to the full the new scientific methods. The improvement in production was, however, enough to meet the demand for more food as the population steadily increased. At the end of the eighteenth century British farming entered a period of great prosperity, which was to last till 1880. About the same time pure science began to develop rapidly and with its new-found strength there arose a desire to apply scientific knowledge for the benefit of mankind. It would have been difficult in England at the beginning of the nineteenth century to overlook agriculture as a possible beneficiary. It is not surprising, therefore, to find Humphry Davy, the young professor at the Royal Institution, giving a course of lectures on agricultural chemistry in 1803 and publishing ten years later his *Elements of Agricultural Chemistry*. In 1840 Liebig published his *Chemistry in its Applications to Agriculture and Physiology*, which showed for the first time the important part which chemistry might play in explaining the phenomena of plant growth and in enabling the farmer to adopt scientific methods for the manuring of his crops. There is little doubt that this work stimulated Liebig's pupil Henry Gilbert to join with John Lawes in founding the great experimental station at Rothamsted, on the work of which our modern fertiliser practice is based.

The chemists were not alone in their interest in agriculture ; almost every science had a contribution to make. The botanists were experimenting with pedigree wheats and barleys, and the engineers were developing new systems of drainage and a whole range of agricultural implements.

The application by the farmers of the knowledge which was being made available was slow, perhaps not surprisingly at a time when the old well-tried methods served to produce enough to give the farmer a satisfactory living. But whilst farming was prosperous, the production of food in Great Britain was not keeping pace with the needs of the now rapidly

growing population in the industrial towns. So once more the common pattern adopted by a community in search of food was repeated. There seemed no immediate possibility of an increased yield from the acres of existing farm land, so attention was turned to finding new undeveloped land. In Great Britain itself there was little chance of making any unused land suitable for farming without spending on capital improvements more than the reclaimed land would fetch on the market, but transport, already greatly improved and soon to be revolutionised by the steam engine, had made accessible the vast empty lands of the Americas, and of the Southern Hemisphere. It was to these lands the people of Britain turned for their food. First they began to grow wheat on the rich virgin soils, then to send their livestock to graze the native pasture.

The methods of production used were like those of the nomad. The settler cropped or stocked a soil, without adding fertilisers or following a sound rotation, until it was worn out ; then he moved on to new land to repeat the process. Wheat was grown repeatedly on the same soil until it became a heap of dust, or grown with an intervening fallow where the land was not good enough for continuous cropping, or the climate too dry, until again the stored organic matter was exhausted. The stock farmer either grazed his herds and flocks on the open unfenced prairie, or he fenced off a holding, dividing it into paddocks. Where the stocking was light, the native pastures regenerated fast enough to maintain themselves. Where, however, the stocking was too heavy, the land was eaten bare and soon degenerated into a waste.

The systems adopted were not, however, truly nomadic in two aspects. As the term 'settler' implies, the pioneers attempted to set up permanent homes and to stay too long in one place. In settlements like the sheep stations in Australia, where the homestead was surrounded by an area of native pasture large enough to give the owner a satisfactory return when lightly stocked, the system was permanent and stable. The wheat farmers, to achieve a similar stability, should have cropped only a small fraction of their land at any time, allowing it then to revert to natural pasture, whilst it still had the fertility to do so rapidly, and leaving it for years under light grazing to regain its original fertility. Such a system would have brought the settler a poor living, so he cropped all his land until it was exhausted and then moved on leaving a derelict waste behind him.

The second aspect in this development of overseas food production not truly nomadic in character was the lack of movement of population. The emigrants from Great Britain going to the new countries were relatively few in number and consumed only a small part of the food they produced. To achieve this production, native labour was used whenever it was available, and machinery, particularly the reaper binder, was introduced on a scale not known in Britain. The settlers, devoting themselves entirely to the farming and prospecting, relied on those remaining behind in industrial Britain to provide all the manufactured goods they needed in exchange for a plentiful supply of food and raw materials. Unlike the truly nomadic tribe, the great bulk of the people did not move to the new food-producing lands, but lived permanently in a large centre of dense population where they were engaged in the specialised production of manufactured goods.

This system, which might be called static nomadism, had a number of characteristics worthy of note.

First, no attempt was made to apply science in the utilisation of the new lands, partly because the pioneers did not know what questions to ask ; partly because the scientist could not have answered the questions which should have been asked without extensive research.

Second, the food produced was cheap, being subsidised by continuous drawings on the capital reserves stored in the virgin lands and by the use of native labour. Cheap food, combined with intensive industrial specialisation, resulted in cheap manufactured goods, which could be advantageously exchanged with other countries.

Third, this extremely advantageous economic system was entirely dependent on keeping transport moving freely ; if it were interrupted the dense population must starve.

And fourth, the nation living in this way had to be powerful enough to prevent others encroaching on its food supply areas.

The United Kingdom exploited this way of living successfully for a hundred years ; in the end too successfully. So great became the quantity of cheap food that it almost ruined farmers at home, whilst the capital assets in the virgin soils on which it drew were being rapidly exhausted. Other nations with growing populations began to demand a share of our cheap food and its accompanying industrial prosperity ; to claim ' a place in the sun.' Ultimately in 1914 one tried to take it by force.

When war partly blocked our transport lines, British agriculture had to try to fill the wide gap between our needs and our supplies. The farmers who had changed their methods little in the last fifty years set about their task, not by trying to increase yields but primarily by bringing back into cultivation land which had been allowed to fall down to indifferent grass during the years of depression. For a short time farming was prosperous, but once ships began to move freely again the pressure of cheap food from overseas was too great to resist and the products of British farms were no longer wanted.

Science could claim little part in the food production campaign of 1914–18, but the study of agricultural science was greatly stimulated by the first danger of famine this country had known for more than seventy years.

Before the first world war a number of far-sighted men had pointed out that British agriculture, if it were to survive, must adopt new methods based on scientific knowledge and that these could only be worked out in the laboratory and on the experimental farm. In 1909 research for the advancement of agriculture received its first direct state-aid through the Development Commission, and plans were laid for the expansion of the work at Rothamsted, Long Ashton, the Universities and the Agricultural Colleges, and for the establishment of a number of new institutes. Under the stimulus created by the war, rapid progress was made, laboratories were built and equipped and young men recruited. Within a few years, however, depression hit not only agriculture but the whole country. The Research Institutes carried on with their work, but growth was halted and recruiting almost ceased for fifteen years. We are constantly reminded today of these blank years by the dearth of men in agricultural research between the ages of forty and fifty-five.

The scientific staffs through all their difficulties held firmly to the belief that good must ultimately come from increasing the output from the land. At the time, when the sale price of farm produce was often less than the bare cost of production, this seemed a crazy notion, or perhaps just wishful thinking arising from self-interest.

To sell any ideas for increasing production to the farmers seemed like asking a man to pay for a rope on which he was to hang. Methods designed to raise production always involve an increase in capital, even if it is no more than a temporary increase, to meet the cost of labour and materials used until the additional crop is harvested and sold. The scientists, in the years between the two wars, found themselves all too often advocating capital investment to a bankrupt industry, in order to produce more goods to sell at a loss. It seemed a hopeless task, yet some farmers listened and tried to act on the advice, partly because they too believed with the scientists that it must be essentially right to produce more food until everyone had enough to eat, and partly from the pride they had in their work, their stock and their land.

When a second world war again disrupted our transport lines, this time more effectively than in 1917 and 1918, these farmers, with the help of the scientists, led a revolution in food production. Once more there was a great ploughing-up of grassland, but it was accompanied this time by increases in the yield per acre and per beast.

The joint efforts of farmers and scientists in raising home food production during the war showed clearly that we need no longer depend on the continuous exploitation of virgin lands to meet our needs. We can produce on our farms at home, and in other lands settled by our own people, the food we want, but to do this we must develop research to the full and apply the findings vigorously in practice.

The value of research was recognised

and between 1944 and 1946 the late Sir John Fryer, the then Secretary of the Agricultural Research Council, prepared a plan for the development of research, which was expected to be completed in ten years. This included the enlargement of existing institutes and the establishment of new ones in subjects for which facilities were not already provided. The plan has progressed, not altogether at the scheduled pace, but steadily and without serious omissions. Delays have not been due to lack of money, but to the shortage of trained men and the lack of buildings. We have learnt again that research cannot proceed in jerks, attempting to make up in a few years the neglect of many. If research is to be successfully developed, there must be a steady recruitment of scientific staff. Once it becomes known that men are no longer wanted for any particular type of work, entrants to the universities avoid training leading to it, and when recruitment begins again there are few applicants with suitable training. The flow of entrants to the universities starts afresh with the knowledge of available openings, but it is five or six years before these students are ready to take the most junior research posts. Now that the men who entered the universities after the war are available, the supply of manpower has improved and the chief difficulty rests in getting building work completed.

The need for the vigorous application of the results of research in farming has also been recognised by the setting up of a chain of Experimental Husbandry Farms and Horticultural Stations, to apply the findings of the research institutes under different conditions of soil and climate, to carry out experiments affected by local conditions and to take the place occupied by the pilot plant in the chemical industry.

This general acceptance of the value of research work and the importance of the application of its results in agricultural practice is part of a great change in our national outlook, in that it is now generally accepted that our hope of survival as a nation depends on greater output from our farms. Whilst we subscribe to this view in public and know it in our minds to be right, in private we too often look back with nostalgia to the time when our nomadic agriculture brought us a plentiful supply of cheap food from overseas and hope vainly for its return. A nomadic tribe must be strong if it is to resist the claims of others to graze cattle and grow crops on the land over which it ranges. So too must a nation be strong both in money and in arms to claim the products of a large part of the earth's available lands and transport them to fill its home larder. Two wars have left us, though victorious, exhausted and weakened, whilst other nations have been gaining in strength, so that we no longer have the power or the wealth to win for ourselves in competition with other nations the same share of the world's supply of food and raw materials as we enjoyed before the war. Once we admit this unpleasant truth, it follows that the only way we can face the future with confidence is by planning to produce much more on the land which remains available to us. Because we still tend to think of our own and the world's food production from the land at present in use as static or even declining, and see no potentially rich productive land unclaimed, we are becoming increasingly alarmed at the apparently inevitable shortage of food for the world's growing population. Now that for the first time as a nation we are likely to be amongst the sufferers, we fail to recognise the disease as chronic with progressive deterioration and instead regard it as sudden and acute. The problem of famine seemed serious when we were discussing the probable suffering of others ; it becomes terrifying when we realise that we ourselves may go hungry. These fears, which have been steadily growing, will prove to have been well justified if we do nothing to meet the danger ; but we can take action that will prove them false if we have the courage and determination to do so. We must farm to the full every acre of land which is at our disposal and try to persuade our kindred overseas to do so too ; applying all our knowledge to achieve this end.

Not unnaturally, the bulk of the nation, who are neither farmers nor scientists, wish to know what is involved before committing themselves to a programme designed to give a high output on existing farm land and to render fertile and bring into full use land of low productivity. They may recognise that it is the only

alternative to starvation, but still they rightly wish to know what is the cost.

Sir John Russell made a brilliant summary of the means by which food production can be raised in his Presidential Address to the Association at its Newcastle meeting. Anyone hearing or reading that address must be convinced of our technical ability to achieve an enormous increase in food production. Sir John, however, added this warning: 'If more food is needed, more work must be done to earn it.' It is clear from the context that Sir John was referring not only to work on the land; he was also speaking of the work involved in producing the equipment and supplies needed for an expanding agriculture.

What will the adoption of a policy of expanding agriculture based on good husbandry and the application of scientific knowledge involve? Will the extra work to be done mean a hard, monotonous and drab existence? Must we, in order to live, lose the joy of life? The answers to these questions depend on how we approach the task. If looking back on our easier past we regard it with anger and irritation as an unfair burden that we should not be asked to carry, we shall make slow progress, resenting each effort that has to be made, and by going to work half-heartedly risk ultimate failure. If, on the other hand, we accept this task as a challenge to our intelligence and strength and attack it with courage and determination, as we did the dangers that faced us during the war, the struggle will be exciting and stimulating and we shall be sustained by an ever-growing prospect of success.

There is a true parallel between the great war-time projects and a major drive for increased food production. It may be suggested that in war there is the consciousness of immediate danger not present in the time of peace acting as a spur to common effort and sacrifice, but famine, although it may be a less tangible enemy than an advancing army, is even more deadly and more ruthless. Once it is clearly understood that, unless we are prepared to attack and conquer this enemy, our comfort, happiness and even our lives may be in danger, the stimulus to action should be enough.

Again, it may be argued that war-time projects, often great in conception and large in scale, fire the imagination so that the most humble duty gains an added sense of importance and urgency, whilst agriculture, lacking these qualities, reduces all effort to the common daily round of work. This may have been partly true in times when farming methods were static, when tradition ruled over everything; it is certainly untrue of an expanding agriculture and of the scientific work which makes the expansion possible.

If we look at the work which is already being done and that which is projected in our own Islands and elsewhere throughout the Commonwealth, we find projects as large and as daring as anything attempted in war, investigations as fascinating as anything told of M.I.5, and victories so complete and final as to go beyond the dreams of the commander in battle. Here are some examples.

The first is a story of land infertile due to lack of water, turned into rich farm lands by the irrigation engineers and of their titanic scheme to change the course of a river and send part of its waters to double the irrigated area. The Great Dividing Range of Mountains follows closely the east coast of the Australian continent until reaching the extreme south it turns at right angles to run due west. In the south-east, roughly where the range makes its sharp turn, the land rises to its greatest height in the Snowy Mountains of over 7,000 ft. Here there is an area of 40 square miles with an altitude of over 6,000 ft. and a rainfall at the highest points of more than 100 inches. From these snow-covered mountains rise the Murray River and its great tributary, the Murrumbidgee, to flow westwards through New South Wales and Victoria, behind and parallel to that part of the Great Divide that runs westward from the Snowy Mountain area. The moist winds from the sea leave most of their water on the slopes of the Great Divide, so that the country through which the Murray and the Murrumbidgee flow on the landward side of the mountains, has a low rainfall of from 20 inches near the mountains to 10 inches further inland. The soils of the river valleys are alluvial; much of the area is covered with good red-brown earths and other fertile soils, but without

water they are of little agricultural value. Engineers, by building dams and cutting canals, have carried the water from the river to irrigate each year an area of more than a million acres—about twice the area of the County of Derry—of fertile land. From sparse grazing it is now producing milk, butter, beef, pork, fat lambs, fruit of all kinds, and rice. More dams and canals are under construction, which will irrigate further areas of equal size, making a total of land irrigated each year of over two million acres. In addition, water for domestic purposes and stock is supplied to a much larger area. These extensions will have absorbed all the available water from these great rivers. No definite estimate has been made of the increased production which will follow the completion of this great network of irrigation, but on the basis of the output figures available for the present irrigation areas in Victoria, where 680,000 acres have yielded £15,000,000 worth of produce, it should be of the order of £40,000,000.

This is a large and ambitious scheme and the Federal and State Governments might well have been content to rest on their laurels but there will still be much good land left unwatered when every available acre/ft. of water has been taken from the Murray and the Murrumbidgee, so the engineers have another plan.

Rising in the same area as the Murray and the Murrumbidgee is the Snowy River, but it flows not west into the dry plain, but south through well-watered country to the sea. To the Australian, who is, over a large part of the continent, always fighting drought, this appeared grossly wasteful. If, he argued, this water flowed west into the Murray Valley instead of south into the sea, then at least another million acres could be intensely irrigated. But a mountain range lay between the head waters of the Snowy River and those of the Murray and Murrumbidgee, so this seemed no more than an idle dream of what might have been until the engineers and geologists got together and produced a scheme—now accepted by the Federal and State Governments—by which a large part of the waters of the Snowy River will be taken through two great tunnel systems under the mountain peaks and discharged on the western side into the Murray and the Murrumbidgee. The tunnel to the head waters of the Murrumbidgee will be 15 miles long, with a sectional area of 900 sq. ft.—the Simplon tunnel is 12·3 miles long—that to the Murray is to be in three sections, the first 8 miles long, with a sectional area of 700 sq. ft., the second 9½ miles long, with a sectional area of 1,150 sq. ft., and the third 4½ miles with a sectional area of 1,500 sq. ft. The cross section of the tunnel is increased as it picks up water from other tributaries through vertical shafts. In addition to these main tunnels the scheme involves many subsidiary tunnels, seven great dams with storage capacity of over 3,000,000 acre/ft. and more than 400 miles of race lines. Apart from its agricultural importance in making possible increased production of the order of £20,000,000 a year, the scheme provides for the generation by water power of 2,500,000 kw. of electric power.

This surely is a project to fire the imagination and to call forth a great co-ordinated effort ; it is as exciting as the original exploration of the Australian continent and calls for courage equal to that shown by the early explorers.

This, it is true, is only one scheme, large in scale and dramatic in its daring conception, but it illustrates well what the engineer is now doing in many parts of the world, and can do increasingly in the future, to bring water to arid but otherwise fertile land. The cost of irrigation may be high, but so also is the return.

There are deserts which do not lack water, but where the land is barren due to the absence of one or more of the elements essential for plant or animal growth. The amount of the missing element required is often very small and large areas of land can be made fertile at relatively low cost.

In parts of Scotland and the south-western counties of England, a nutritional disease of sheep has been recognised for over 100 years. The name 'Pine' describes the disease well ; the young lambs gradually waste away and die. The only remedies known were to move the lambs to unaffected pasture or to bring soil from other districts and give it, mixed with water as a drench. The same symptoms were observed in other parts

of the world, particularly in Australia and New Zealand.

It was thought the disease might be a form of anæmia and ferrous sulphate was tried as a remedy with varying results. After further experiments it was shown by Marston that the so-called ' Coast Disease ' of the Southern Australia littoral, and by Underwood and Filmer that Enzootic Marasmus in Western Australia, responded dramatically to small doses of cobalt given by mouth. Animals could be kept healthy on the deficient pasture and those already seriously affected responded rapidly on receiving doses of one milligram of cobalt a day. Other workers soon established that cobalt deficiency was responsible for Pine in the Cheviots and many other parts of Scotland, whilst in England the same condition was proved to exist in Devon, Cornwall and Worcestershire. Bush Sickness, which occurs on large stretches of the pumice soils of New Zealand, was also shown to be due to lack of cobalt. Salt Sickness in Florida and Makuruitis in Kenya were later added to the list of diseases responding to treatment with cobalt. Marston, who has made an extensive study of this subject, has recently stated that there are probably many other parts of the world where animals are seriously affected by lack of cobalt and where its administration would produce the same striking results. Cobalt is not the only element having remarkable effects when applied to deficient soils in small quantities or when fed to stock grazing deficient herbage. Low concentrations of copper, molybdenum, boron, manganese, magnesium, zinc and sulphur have all been proved to be responsible for failures either in crops or in stock. Frequently the trouble arises from the lack of two of these elements or from the excess or lack of one rendering another unavailable. All areas where the yields of crops and stock fall below those normally to be expected from the soil and climate must be regarded as probably deficient in some nutrient and examined in the hope that the cause of the lack of fertility can be found and set right.

There is often a complex relationship between soil, plant and stock which makes the problem difficult of solution. The South Australian Area in which Coast Disease occurs consists of two soil types, the one composed of calcareous marine shell fragments ; the other of siliceous sands. Sheep grazing on both these soil types responded to treatment with 1 mg. of cobalt per day, but another syndrome then appeared which had been previously masked by the more immediate effects of the cobalt deficiency. This proved to be due to a lack of copper. When both cobalt and copper were administered the sheep grew satisfactorily and remained healthy.

The next problem was to get a sufficient growth of pasture and other crops to feed larger numbers of sheep. Applications of the normal fertiliser mixtures of phosphate, potash and nitrogen failed to produce good yields of cereals or to establish pastures of sown grasses and legumes. It was then found that on the calcareous soils the lack of growth of plants was also limited by the copper deficiency and that a dressing of 7 lbs. per acre of copper sulphate enabled cereals, legumes and grasses to respond fully to dressings of the major plant nutrients.

The addition of copper to the siliceous sands did not, however, produce the same results and it was only after further years of experiment that Marston completed his great work by showing the lack of plant growth on these soils was due to a deficiency of zinc. To drive through the untreated areas and then to come quite suddenly on the improved pasture is to know what the prophet meant when he spoke of the desert being made to ' rejoice and blossom as the rose.' Nothing could be more rewarding and exciting than the work of the farmers and scientists in converting these wastes into fertile lands. The total effect on food production cannot as yet be estimated ; all we know is that it must be very large, as the hundreds of square miles involved are suitably treated and divided into farms supplied with the necessary buildings and fences.

The examples so far given have been of bringing infertile land into use, but an equal, or possibly greater, contribution to our food supplies can be made by increasing production on existing farm lands. There are two ways of doing this : the one by increasing yields, the other by

preventing waste. It has been pointed out often that the average yields of crops in the United Kingdom are much below what the best farmers expect as their normal return. There has been since the beginning of the war a steady increase in the average yields of our crops ; that of wheat, for example, has risen by approximately 10 per cent. This may seem in itself satisfactory, but it appears less so when the present average figures of about 20 cwts. per acre are compared with the 30 cwts. on light land and 40 cwts. on strong land obtained by many good farmers. The difference here also lies in the full application of scientific knowledge. High yields depend on the use of a variety bred and selected to suit the conditions of soil and climate, the application at the right time and in the right way of the amounts of the different fertilisers, which have been shown by the soil chemists to give optimum yield, the proper cultivation of the soil and the effective control of pests and diseases.

These sound practices are, however, not fully effective if the soil is not at the same time kept at a high level of fertility. In the United Kingdom we have never entirely forgotten the teaching of our great farmers on the need for a sound rotation, including crops to be eaten by stock in the field, but we have found their precepts difficult to follow in the years of depression and of rising working costs. The hurdled flock and the bullock yard on which fertility was based have largely disappeared and the arable land has been used to an increasing extent for cash crops. Increased use of fertilisers and improved methods of controlling weeds and diseases have counteracted the loss of yield that would have inevitably followed the resultant lowering of fertility.

In the years immediately before the War the agronomists, led by Stapledon, took up the old idea of the ley and developed it as a means of maintaining output under modern conditions, whilst at the same time building up the fertility of the soil. The replacement of permanent grass by well-grazed short-term leys of three to four years, covering every field on the farm in turn as part of the normal rotation, or where there was no permanent grass the introduction of a similar ley to replace the root break and the one-year ley in the old four-course rotation, is now well understood and generally accepted.

We do not know yet how great a revolution this modern system of ley farming has brought about ; we expected an improvement due to the reintroduction of stock on the arable land, but the scientists themselves have been surprised at the results achieved and are now busily at work seeking the explanations of the unexpected success, in order to define the conditions under which the ley produces the maximum benefit.

It is known already that the more productive the ley and the heavier the stocking, the better the arable crops that follow ; we know too that a ley should always be broken whilst it is highly productive and that the arable land should be resown to a ley whilst its fertility is still high. In this way the fertility of the land can be steadily raised and year by year the crop yields increased ; we cannot say what the maximum yields will be ; the time may come when a yield of two tons of wheat per acre may be regarded as the normal.

Ley farming must also find an increasing place throughout world agriculture. Land that has been continuously cropped must be rested under a sward grazed by animals and the native pastures that carry few animals must be fertilised and sown to new grasses and legumes, if they are to make their full contribution to the world's larder. Each set of environmental conditions into which these methods are to be introduced needs careful scientific examination. Ley farming on the lines of the best British practice would result in disaster under an inadequate rainfall and a sub-tropical sun. We have to learn to farm afresh in every region which passes from an extensive nomadic type of agriculture to a more permanent and more intensive system of cultivation ; to change from the one to the other without a full scientific study and careful pilot experiments is folly. If we grow heavier crops we must protect them from pests and diseases. The loss of food due to the attacks of wild animals, insects and plant diseases is, we know, enormous.

In a recently published book, *Untaken Harvest*, George Ordish has summarised the existing information about crop losses.

He reaches the conclusion for Great Britain that in the year 1947, after spending £10,000,000 on the control of insect pests and diseases, the losses from these sources were equivalent to £78,000,000 and expresses this graphically by saying that it is equivalent to 33,000 of our farms producing no crop, and 51,000 skilled farm workers achieving nothing with their labour.

To this must be added the estimates for the damage caused by rabbits and rats. Rabbit damage in Great Britain has been estimated at £50,000,000 per annum, and that by rats at £40,000,000.

All these figures are estimates and the damage must vary from year to year, but it would be safe to assume the total damage to average more than £100,000,000 per annum. The chemists, entomologists and plant physiologists are waging a continuous war against these enemies and have won some remarkable successes since 1947, but there is still much to be done. It seems idle to begin to speak of food shortage whilst we are losing more than 5,000,000 tons of food each year, and not putting into the battle the effort we should have made to save so large an amount in war time.

The proportional losses in other countries are as high. Ordish calculates that the losses in South Africa are equivalent to 500,000 acres, and the loss through fungus attacks on cereals in Australia as equal to the yield of over 900,000 acres. The same picture can be found in every country, varying in type and extent, but everywhere representing a very considerable fraction, often as high as one-fifth of the potential output.

What has been said of increases in crop production and losses due to pests and diseases can be repeated for the animals on the farm. The output of milk, meat and eggs depends on good stock, the right management, and the control of disease. Figures given for possible improvement in the conversion of crops and grass into animal products are little more than inspired guesses. They all agree, however, in assessing the figures as very high. It would be conservative to estimate a 20 per cent. increase in the output of animal products from the same amount of feeding stuffs if the level of production on all the farms in Great Britain could be raised to the level, not of the best, but of the good, by the application of existing scientific knowledge. In few countries would the increase be less and in many countries it would be much higher.

These examples of what could be done to expand agricultural output by the application of science serve to show that the world's food production is far below the maximum.

The rapidly increasing human population presses hard on the heels of available food supplies and if production remains static, famine is inevitable. The control of population will come with the spread of education, but it will be a slow process; in the meantime the number of people to be fed will continue to rise rapidly. We have in the expansion of production the only means to ward off this danger which threatens the whole world, and particularly dense centres of population such as the United Kingdom.

This is not a war to be fought by the farmers and scientists alone; it is a war in which every man, woman and child is vitally concerned, and in which each can play his part.

Increased food production will require great efforts, and for a time sacrifices. Every development on the farms will call for increased equipment, labour and materials. Whether it is an irrigation scheme, the cultivation of land rendered fertile by proper chemical treatment, the increase in crop and animal yields, or the control of pests, more machinery, more fencing, more buildings, more fertilisers and more chemicals will be needed. The provision of these material requirements will, however, in itself be of little avail unless we intensify at the same time our efforts to carry scientific knowledge to the farmers, and continue unhesitatingly to develop research, the spearhead of all progress. Marked increases in food production occur only in times when there is a strong flow of new scientific knowledge being actively applied in practice.

Now more than at any other time in the world's history is that increase needed. Have we as a nation, has the world as a whole, the faith and the courage to set aside from our available supplies of trained men and materials, those needed for the scientific expansion of agriculture? On the answer to this question may rest the fate of mankind.

TEXTILE FIBRES OF PAKISTAN[1]

by

DR. NAZIR AHMAD

BEFORE I tell you something about the textile fibres of Pakistan, I would like to say a few words, by way of introduction, about the country itself which is a new State, established only five years ago, but a very old land going back, in culture and civilisation, many thousand years. Pakistan is composed of two parts lying at the extreme ends of India which, though separated by land, are united by sea and air.

Western Pakistan consists of the provinces of North-West Frontier, Punjab, Sind and Baluchistan and the States of Bahawalpur, Kalat and others. It has a total area of 310,298 square miles and a population of about 33 million people. It has high mountains in the north and north-west, but the rest of the country is an alluvial plain through which flow five rivers: Jhelum, Chenab, Ravi, Beas and Sutlej. An extensive irrigation system has been built up in which the waters of these rivers have been utilised to irrigate some 23 million acres, while two new irrigation projects have been started recently to bring another 4 million acres under irrigation. Many kinds of food and cash crops (wheat, rice, maize, sugarcane, cotton, tobacco, etc.), grow on these irrigated lands, which are sometimes referred to as the Indus basin.

Eastern Pakistan, which is composed of East Bengal and Sylhet, has an area of 53,920 square miles and a population of over 42 million people. Except for some low hills in the extreme south (the Chittagong Hill tract) it is a flat country through which the mighty rivers Ganges and Brahmaputra flow to the sea. It has a heavy rainfall and needs no irrigation works to feed its 25 million acres on which the main crops are rice and jute.

[1] Lecture delivered to young people during the Annual Meeting at Belfast, September 8, 1952.

The textile fibres of Pakistan are cotton, jute and wool.

COTTON

With the exception of a few thousand bales grown in Eastern Pakistan, the bulk of Pakistan cotton is grown in Western Pakistan in the Indus basin. Unlike the American cotton belt, which runs in an east-west direction, the Pakistan cotton belt runs approximately in a north-south direction in the Punjab, Bahawalpur and Sind, very little cotton being grown in the North-West Frontier Province and Baluchistan. The cultivation of cotton in the Indus basin is not a recent development ; it goes back to the dawn of history, to about 2,500 or 3,000 B.C. At that time a civilisation flourished along the banks of the River Indus, people lived in cities having straight paved roads and drainage systems. These remarkable people, whose buried towns were unearthed some years ago, had learnt the art of growing cotton which could be spun, and made fabrics from it. Bits of these fabrics, about 4,000 to 5,000 years old, were found clinging to some of their household goods such as razor blades, beads, etc., and on examination proved to be made from cotton. The man who first examined these ancient fabrics and established the antiquity of Pakistan cotton as a textile material is Dr. Turner, the present Director of the Linen Research Institute in Northern Ireland.

From those ancient times cotton has been continually grown in the Indus basin and used as a textile fibre. The fact that a textile fibre was obtained from a plant was, in the past, a source of wonder to many people in the West, who were acquainted only with wool ; and there is an amusing painting in which tiny lambs are shown delicately perched in the middle of flowering buds on a plant, which the

artist imagined yielded the cotton fibres. Until the beginning of the twentieth century, the cotton grown in the Indus basin was largely of the local type known as *desi*, which is short stapled, rather rough to the touch and can only spin coarse counts. Towards the beginning of the twentieth century, however, efforts were made to introduce and acclimatise Upland seed from the U.S.A. ; and these efforts proved eminently successful. Today, more than 90 per cent. of the cotton grown in the Indus basin is of the American type, comparable to the American middling, and possessing a fine fibre which can be spun into medium-fine counts.

Although the cultivation of cotton in Eastern Pakistan does not, like Western Pakistan, go far back in history, the Province acquired fame, during the Middle Ages, for the excellence of its cotton fibres. Many of you must have heard of the Dacca muslins, which were so fine that a whole piece of forty yards weighed but a few ounces and could be easily passed through a ring. Such fine yarns were spun by hand and the weaving was done on small hand-looms by skilled workers ; but alas, such fine handicraft could not withstand competition by machines ; and to-day, apart from the few museum pieces, only the poetic names like ' the morning dew,' ' the flowing stream,' etc., are left to remind us of this wonderful art.

In the Indus basin, cotton is planted in March and April, and is ready for picking from the middle of October. The land is mostly prepared by ploughs driven by bullocks. Lately, however, some mechanical farming has been introduced. The picking season extends up to the middle of January, the cotton in Sind being picked somewhat earlier than in the Punjab. After the first few months of growth the plant bears flowers which are white with yellow centres. When the flowers shed, bolls appear, and steadily grow in size. They are pear-shaped, and ultimately become as large as medium-sized plums. Each boll contains a number of locks of tightly packed seeds, and on each seed are cotton fibres. At a certain stage of development the bolls burst open, and the fluffy mass of fibres sticking to the seeds is ready for picking. All the bolls on a plant do not open at once, and that is why the picking period extends over two months or more, during which there may be three to five pickings. The middle pickings give the highest yield, and their quality is considered better than that of the extreme pickings.

The period when the fibres are growing on the seeds inside the boll may be divided into two halves. During the first half of this period, only the elongation of the fibre takes place. The fibre then resembles a very thin tube full of sap. During the second half of the period, there is no further elongation, but layers of cellulose are deposited inside the fibre and this process is known as secondary thickening. One layer is deposited in one day, and if a section of the fibre is cut, and viewed under a microscope, a number of rings can be seen, rather like the growth rings of tree. When the boll bursts open, all the sap dries up, and the fibre collapses, taking natural twists or convolutions, which are a great aid in spinning as they help the fibres to hold together.

When the cotton is picked from the bolls, the fibres are still adhering firmly to the seeds, and have to be detached from them. This is done on machines called gins and the process is called ginning. There are two types of machines, roller gins and saw gins, and in Pakistan, most of the cotton is ginned on the former. Quite often, the seed-cotton is first passed through some cleaning machines to remove dust, leaf, etc., before being fed to the gins.

It must not be imagined that after cotton is planted and before it is ready for picking, the plant has an easy time. If it does not suffer from drought or early frost or late rains, it has many insects as enemies. There is, for instance, the jassid which may attack and suck its juice, or the boll-worm which may lay its eggs inside the bolls and whose offspring may eat it from inside. Then there is the white fly which may exact its toll, and the locust which may visit occasionally but on each visit may eat up whole fields. One of the many duties of scientists is to devise ways and means of fighting these insects or of evolving varieties of cotton which resist them, and for this purpose they have to make a thorough study of the life histories and habits of the insects and the plant.

Apart from possible damage by insects, the cotton plant has a tendency, if left to itself, to degenerate in course of time due to mixing of seeds and natural cross-hybridisation. Continuous work is necessary to maintain the quality of cotton by the supply of reasonably pure seed from farms where cotton is grown under proper supervision and also to improve the quality by evolving better varieties. Improvement of quality is achieved by selection in the fields or by hybridisation or by importation of better quality seeds from other countries and their acclimatisation to local conditions. In Pakistan all the three methods are being employed to evolve better varieties of cotton and to reduce the damage by insects. In order to do this work successfully, the Government of Pakistan have set up a Cotton Committee and provided it with funds to employ scientists. Since cotton is grown to be spun, and spinning tests and fibre tests are necessary to determine the quality of cotton, the Pakistan Cotton Committee is setting up a fine Institute of Cotton Research and Technology at Karachi which will be one of the largest of its kind. It is hoped that work in this Institute will begin early in 1953.

The total area under cotton in Pakistan is approximately 3 million acres, and the crop raised every year is of the order of 1·5 million bales, each bale containing a little under 400 lbs. of cotton fibre. Pakistan has not, as yet, many cotton mills of its own, and exports the bulk of its cotton crop to other countries. In 1951 Pakistan exported nearly 1·2 million bales and consumed the rest within the country. Cotton mills are being set up in Pakistan, and soon the consumption of cotton within the country will be appreciably larger. However, in order to maintain exports we are bringing more acres under cotton cultivation. It is estimated that in the next five years another 600,000 acres may be brought under cotton giving at least an additional 300,000 bales per annum. At present Pakistan is the fifth largest producer and the second largest exporter of cotton in the world.

Jute

While the bulk of the Pakistan cotton is grown in Western Pakistan on irrigated lands, jute is cultured exclusively in Eastern Pakistan where the heavy rainfall and moist climate are favourable to its growth. Unlike cotton which is a seed fibre, jute is a bast fibre. It is formed on the outside of the plant round the woody core, and in this respect resembles flax which constitutes the raw material for one of the principal industries in Northern Ireland. The jute is planted just before the monsoon in March and April and is ready for harvesting in July and August. The average height of the plant is 8 to 10 feet, though taller plants are not unknown. When the plants are fully grown, they are cut near the roots and tied in bundles which are left three to four days to allow the leaves to drop off. The bundles are then submerged in water for ten days to three weeks, the process being known as retting. During this period, fermentation takes place and the woody core becomes quite soft. The bundles are then gently thrashed with wooden mallets to remove the woody core which drops off in the water, and jute fibres in long strands are recovered and tied in bundles. All this work is done by hand by people who often have to stand ankle or knee deep in water. When the jute fibres are dry, they are tied into bundles. As the jute grows mostly in the villages in Eastern Pakistan it has to be sent to big towns like Dacca and Narangunj for further processing. For this purpose flat-bottom barges are used to convey these bundles from the villages to the big towns where the jute is graded and pressed by machines into bales weighing approximately 400 lbs. each. These bales are then stored in godowns waiting to be shipped abroad. The United Kingdom is one of our principal buyers, purchasing 400,000 to 500,000 bales per annum. The jute grown in Eastern Pakistan is of two main varieties—white jute, known locally as *Pat* or *Koshta*, and yellowish brown jute known as *Dessi*, *Torsa* and *Bogi*. Each variety is grown in certain well-defined areas.

The processing of jute fibres, which are 6 to 8 feet long, is rather like that of the flax fibre. However, as jute is a much coarser fibre, it is naturally used for coarser fabrics. The yellowish brown varieties are used for making ropes, gunny bags for wheat, cement, sugar,

grain, etc., while the whiter varieties are used for hessian and for jute yarns which are used as a base for woollen carpets. Much work has recently been done to extend the use of jute to other purposes, e.g. laminated boards.

The total area under jute varies from year to year and depends upon the decision of the Government which takes into consideration the existing stocks, the likely demand, the trend of prices and so on. The actual area may be between 1·5 and 2·5 million acres, and may yield a crop of 4·5 million to 7·5 million bales of 400 lbs. each. The area in 1947–48 was over 2 million acres, in 1948–49 it was 1·88 million acres and in 1949–50 it was 1·56 million acres. Pakistan grows nearly 75 per cent. of all the jute grown in the world.

As in the case of cotton, botanical work is necessary in order to improve the quality of jute, while technological work is necessary to find its best uses and optimum working conditions in the jute mills. We have botanical farms at Dacca and other places, where botanical work is in progress, and recently plans have been prepared to set up a jute Technological Institute at Dacca. As in the case of cotton, the Government have established a Jute Committee to initiate and co-ordinate work on the improvement of jute from its cultivation to its manufacture, and the Committee, as a first step, has taken in hand the task of setting up the Institute.

Until recently Pakistan had no jute mill of its own, and all the jute grown in the country had to be exported, the United Kingdom being one of the principal importers for its Dundee jute mills. We are now planning to set up immediately five large jute mills of which one has already commenced working. As the area under jute can be increased considerably, there is no danger of our not being able to supply sufficient quantities of jute to foreign buyers after our own mills start working. Thus, the jute exports of Pakistan, which are 5 to 6 million bales per annum, can be maintained at the present level.

Wool

By comparison with cotton and jute, the production of wool in Pakistan is quite small, being of the order of 20,000 bales of 400 lbs. each per annum. Of this, about 5,000 bales are used up in the country, while the balance is available for export. Furthermore, Pakistan wool is of a lower quality, than, for instance, Australian wool, and can be used for making coarse tweeds ; but it is mostly used in the manufacture of carpets, and is hence known as carpet wool. There are a number of weaving factories in Pakistan for making woollen carpets, and it is quite interesting to watch the weavers work out intricate patterns without any mechanical aids. Until recently there were no spinning factories for wool but one spinning factory has recently been started at Karachi and three others are in the course of erection near the woollen producing areas in the North-West Frontier Province and in Baluchistan. In order to improve the quality of our wool, we are sending students to Australia for training, and the Government is putting up a Woollen Grading Centre, near the Cotton Research Institute at Karachi, to help in the better grading and marketing of wool by the application of scientific methods.

Textile fibres like cotton, jute, wool, etc., are the sinews of trade and commerce ; and just as individual fibres are held together to strengthen one another in twine or thread, so let us hope that trade and commerce in these fibres may hold together, to their mutual benefit, producing and consuming countries, especially within the Commonwealth.

UPPER ATMOSPHERIC PHYSICS[1]

by

PROF. D. R. BATES

THE aim of the research being done on the Earth's upper atmosphere is to determine the chemical constitution, temperature and density at various altitudes, and to understand the many subsidiary effects associated with it, such as the aurorae of polar latitudes, the faint luminosity or airglow persisting throughout the night at all latitudes, and the ionised layers which make possible long distance radio communication. These various aspects are closely connected and none can be studied properly in isolation. It is, of course, also necessary to take account of the influence the Sun exerts on the atmosphere through its electromagnetic and corpuscular radiation. Much of the radiation does not penetrate to ground level so that, until the problems of instrumentation involved in the use of rockets are properly solved, its intensity and energy distribution cannot be found by direct observation and must instead be inferred from the study of the detailed properties of the atmosphere. This is a formidable task since the theories of these detailed properties are not easy to develop fully without a knowledge of the intensity and energy distribution of the radiation in question. Consequently progress is slow and uncertain. It depends to a considerable extent on the old-established method of trial and error ; and the number of trials may not yet have exceeded the number of errors. The present paper gives a brief survey of only a few selected topics of upper atmospheric physics.

EFFECT OF PHOTO ACTION OF SOLAR RADIATION

Each 100 parts of dry air at ground level consists of 21 parts of molecular oxygen, 78 parts of molecular nitrogen and 1 part of the chemically inert argon together with a small amount of other gases such as carbon dioxide. It was at one time thought that hydrogen and helium would predominate at high levels because of their lightness, but it is now known that in fact these light gases escape from the Earth's gravitational field into interplanetary space, and the general view is that mixing effects keep the relative abundance of the elements much the same as at ground level. However, important changes do take place due to the photo-chemical action of the solar radiation. It is known that part of the ordinary molecular oxygen is converted into ozone and that the atmosphere contains a layer of this substance, the peak of which is located at an altitude of about 15 miles. Purely theoretical work by Professor S. Chapman and others shows that in the region above the 60 mile level the molecular oxygen must be completely broken down into atoms. The position concerning nitrogen is still the subject of controversy. On the one hand the spectra of aurorae suggest that the molecular form is still abundant even at the great altitude of 500 miles ; and on the other hand there is some observational evidence that dissociation into atoms is significant even at an altitude of about 60 miles (as for oxygen). Attempts have been made to calculate the relative abundance of the two forms of nitrogen at various levels from the rates of the various photochemical processes likely to be of importance but these are so complicated that success has not yet been achieved. The whole problem is one of the most important in upper atmospheric physics.

EFFECT OF HUMAN ACTIVITY

Surprisingly enough, some aspects of human activity may have appreciable

[1] Substance of a paper read to Section A (Physics) at Belfast on September 5, 1952.

influence on the abundance of some of the minor constituents of the atmosphere. For example, coal-mining operations to date have resulted in the release of some 20 million million cubic feet of methane which is a significant fraction of the total amount of methane actually occurring. Again approximately 4 million million cubic feet of the poison carbon monoxide are vented into the atmosphere each year from the exhausts of motor vehicles. Within about five years this would double the amount now present if it were not for the fact that there are processes which destroy the gas. The nature of these is still under investigation but it is believed that they involve soil micro-organisms.

It is worth noting that it would be possible to make an *observable* local change in the constitution without undue difficulty. Free atomic sodium is normally present at altitudes of about 40 miles. It is an extremely rare constituent—perhaps about a million million times rarer than oxygen or nitrogen. In spite of this its chemical activity is such that the characteristic yellow light associated with it is a prominent feature of the night and, more especially, the twilight sky luminescence. Since the abundance is so low it could be increased significantly by ejecting atomic sodium from a rocket. It is estimated that the ejection at the 40 mile level of even a few ounces would give rise to a luminosity which at night might be comparable to Venus and during twilight might be comparable to the full Moon.

Temperature and Density

The distribution of temperature and density are intimately connected, one being deducible from the other. Attention is therefore confined to the former, which is easier to discuss than the latter. Recent researches have provided reliable information up to altitudes of about 70 miles and the main problem for the future is the exploration of the region above. While precise figures are not available there is evidence from a variety of sources that the temperature rises rapidly in this region, reaching a value of perhaps 1,500 degrees absolute (which is approximately the melting temperature of iron) at an altitude of about 150 miles. This raises the problem of explaining how such a great temperature is maintained against the cooling effect of thermal conduction and of the emission of energy in the form of infra-red radiation. Calculations show that the heating effect of the Sun would be insufficient if the effective temperature (which is a measure of the intensity) of its unobserved ultra-violet emission were the same as that of the observed visible emission. It seems necessary to conclude that the effective temperatures are not the same: that is that the intensity of the Sun's ultra-violet emission is far higher than would be expected from the intensity of its visible emission. As the ultra-violet radiation is responsible for the ionised layers in the earth's upper atmosphere, the theory of the formation and equilibrium of these may be affected.

THE LOGIC OF EXPERIMENT[1]

by

DR. J. BRONOWSKI

THE use of mathematics to describe the whereabouts of moving bodies, in astronomy and mechanics, has an ancient history; it was thought natural long before Copernicus and Galileo. But the notion that mathematics is central to all science is younger. If we want to fix its birth in a single dramatic date, we may choose the night of November 10, 1619. That night the young Descartes (he was twenty-three) had a mystical experience in which it was shown to him that the key to the universe is its mathematical order. He spoke of that moment with awe, not as a discovery but as a revelation, to the end of his life.

Since Descartes had in mind a mathematics of order, he was looking for a kind of geometry. He wanted to find in the world what he had found in Euclid. Yet mechanics then, as now, more often described events by numbers than by their configuration. It was therefore appropriate that Descartes became a pioneer in the use of graphical methods to link geometry with arithmetic. The notion of imposing a gigantic co-ordinate system on the universe was certainly, in Descartes's mind, one step in giving it a logical order.

Within a few years of Descartes's vision, something very like it changed the life of Thomas Hobbes. It was of course a more sober affair; Hobbes picked up the first book of Euclid, perhaps in the library of his patrons the Cavendishes, and actually read it. He was by then a man of middle age, but he had had a classical education, and he seems to have been unprepared for the heady pleasure of reading a book in which the assertions actually form an argument. In the phrase of his friend Aubrey, 'This made him in love with geometry.'

[1] Paper read in Section A (Mathematics and Physics) on September 5, 1952, during the Annual Meeting in Belfast.

It was plain to Hobbes that the world could be as rational as Euclid, if he could find in its progression some analogue to logical entailment. He found this analogue in the principle of cause and effect. Hobbes held that a cause entails its effect as rigorously as Euclid's axioms entail the *Pons Asinorum*. In fact, we use the verb 'to follow' to describe both kinds of consequence, as a matter of course.

The Axiomatic Method

The triumphant work of the great generation which followed (I use the word advisedly), with Newton at its head, grew from the conception of Hobbes and Descartes. That generation abandoned once for all the attempt to deduce the laws of nature from her facts, by any process of forward reasoning. Instead, the new scientists invented a more tentative method. They singled out a set of principles or axioms, such as Newton's laws of motion and the law of inverse squares; they worked out what kind of a world would follow from these; and they judged the axioms right or wrong by checking their fictitious world against the real world. Huygens puts this clearly in his *Treatise on Light*, where he says 'Here principles are tested by the consequences derived from them.' In my view, this is the essence of the inductive method.

Huygens also saw that this inductive method can never establish its axioms conclusively, because there may (and indeed will) exist other sets of axioms with the same physical consequences. It was on this ground, and this alone, that Huygens thought natural science less certain than geometry: because he thought the axioms of geometry to be self-evident.

The classical criticism of scientific inference was made fifty years after Huygens

wrote this, by David Hume in 1739. He says bluntly :

> ' All reasonings concerning cause and effect are founded on experience, and all reasonings from experience are founded on the supposition, that the course of nature will continue uniformly the same.'
>
> ' We are determined by CUSTOM alone to suppose the future conformable to the past. When I see a billiard-ball moving towards another, my mind is immediately carry'd by habit to the usual effect, and anticipates my sight by conceiving the second ball in motion. There is nothing in these objects, abstractly considered, and independent of experience, which leads me to form any such conclusion : and even after I have had experience of many repeated effects of this kind, there is no argument which determines me to suppose, that the effect will be conformable to past experience.'

Hume has here seized an important point. The events of nature take place in time, which is a dimension that we cannot explore at will. In this they differ from the theorems of geometry as Hume conceived them, embedded in a space in which he was free to move to and fro as he pleased. In an odd way, Hume's generation had suddenly grown aware of the frightening uncertainty of time. It was in his lifetime that crowds marched through London shouting ' Give us back our eleven days,' just 200 years ago as I speak today.

Two Uses of Time

Yet if we look at Hume's objections carefully, we see that they confuse two distinct ways in which time enters into scientific inference. When I say that the dog has evolved from a wolf, I state one kind of theorem which relates to time. And when I say that my dog will have puppies next month, I state another kind of theorem about time. The evidence for both theorems lies in our experience, without which we cannot hope to know the world as it is. Both theorems may therefore be wrong because I have misunderstood experience. And this is the only way in which the first theorem can be wrong : because I have misread the past. But this has nothing to do with Hume's criticism, that the future may *at any future moment* decide to break with the past. A future change in the laws of nature can only affect theorems of the second kind ; it can only stop my dog from having puppies. But it comes too late to falsify the theory of evolution.

It was Hume's point that the laws of nature may turn topsy-turvy at any moment. At midnight we may step into a hole in time and pitch on our heads. As an objection to prediction, this is of course unanswerable : as unanswerable as solipsism, and as pointless. For it simply asserts that there can exist no sanction, *within our experience*, which allows us to step from the territory of our experience into what lies outside it. Mathematicians are taught this in childhood when they are warned that it is unwise to extrapolate. And in my view this objection holds for space as for time. We might equally stumble on a hole in space across which the laws of nature change abruptly. In this vein it is open to anyone to believe that the light which reaches us from distant nebulae is not reddened by the Doppler shift, but by crossing a discontinuity in the laws of physics which cuts off our galaxy like a picture frame. Believe it, and welcome ; but what help is it ? None.

The purpose of science is indeed prediction beyond our experience. But its practice stands apart from these speculations, because they offer no guide alternative to experience. When we ask ' How is a scientific theory made ? ' we always have in mind a way of arranging the facts of experience. We may have to add to these facts by experiment. We may have to wait to prove a theory incomplete or plain wrong. But after that, what we use is always a set of facts *in the past*. The future in the sense of Hume, a time that may have a hole in it, does not exist in science. At any instant, the scientist has only a record of the past—and he must assume that when he plays the record, he experiences the past truly. He is now asked to give order to these experiences. This order is his theory.

Time in an Axiomatic Theory

How the scientist teases out such a theory from the facts or processes which he

has recorded is the crucial question of the later part of my paper. But the form of the theory I have already implied ; it was stated by Huygens. The scientist postulates a set of entities which he supposes, as it were, to lie under the recorded events : atoms or quanta or cells or genes or reflexes. He formulates axioms which these entities are to obey, and allowable operations on them. Of course many of his axioms are not stated explicitly ; but the history of Euclid, from the time of Playfair to our own day, shows that this happens to the most scrupulous geometer. To this apparatus the scientist adds a dictionary to say what conjunctions of his entities can be observed, and what these observable appearances are. And thereupon he sets his model going.

I say ' sets the model going,' and the metaphor is meant to underline the importance of time in this system. For let there be no mistake about this : our theory at any moment describes only the past, but this by no means removes time from it. To suppose that all statements about time must refer to future time is precisely the confusion which I criticise in Hume.

A scientific theory describes the behaviour of things in time. Its axioms must include some which say how the postulated entities move or change in time. Axioms of this kind are essentially rules of cause and effect—where I use these words in their widest sense, to include sequences in which the regularity which is laid down is only statistical. And no scientific theory exists until it has causal rules of this kind, to fix behaviour in time ; even though all the times are past times, as in geology.

By what test is such a theory to be judged ? Can we dispense with the test of prediction ? Of course we can. We are at this stage not concerned with the future use of the theory, but with its success in bringing order to the record which we are given. Our test is therefore the ability of the model in its action to match the record. This is what made relativity in 1905 a more exact theory than the mechanics of Newton. When we enlarge the record by experiment, say by the eclipse of 1919, the added sharpness derives not from prediction but from decision : the experiment is designed *to choose between two theories.*

The Experimental Record as a Sample

Yet clearly no experiment can decide between all theories. However full we make our record, it cannot decide between all possible models. For every record is finite, and can therefore be fitted by an infinite number of models. The record is only a sample, even of the history which it records. It is the nature of all experience that it only samples the universe.

If all our observations are only samples of nature, then plainly the way in which they match the scientist's model of her remains a rather loose test. We can fit the model to the facts only here and there ; and anyone who has ordered a suit by sending his measurements through the post will know that this way of fitting leaves a large room for error. We try to cut down the error by experiment, that is by increasing the size of the sample.

Since we always have to experiment in the future, this may seem to beg the question that Hume asked. How do we know that the future will be ' conformable to the past ' ? The answer is that we do not know ; and we do not suppose it. We look at *the whole of the enlarged sample* when we have taken it : every experimenter knows that. We look for the effect of time—catastrophic or systematic —as we look for the effect of space or orientation or any other variable. In time, as in the other variables, we are concerned with relations ; when we say that two days are the same, we may have to use that word as we do of the weather, to mean that both are changeable.

It is therefore proper to say that the purpose of experiment is to increase the size of the sample on which a theory is tested. In this, experiments are not all alike. Good experiments are more systematic than the random samples yielded by mere observation. And critical experiments are highly stratified samples in the variables under scrutiny. But however well the model fits nature at the sample points, the reasoning from there to its fit at all points can only be probable. It is in this sense that induction gives only a probable assurance of the rightness of a

scientific theory, as Huygens well saw. All forms of sampling give only probable information about the population from which the sample is drawn. In testing a scientific theory by experiment, we try to get information about a population of natural events from a sample. We try to convince ourselves that this population matches the configurations generated by our model everywhere, by showing that they match at the sample points. A good deal of nonsense has been talked about probability in science by those who have missed this conception. Some philosophers speak of probable theories and some even speak as though facts can be probable. Facts are so or not so; observations are true or false; and theories are right or wrong. All that is probable is the assurance that we can have in extending what is known in experience to what is unknown—in arguing from a known sample to a larger unknown one.

A Sample of Properties

But when I have said that our observations are only a sample of events, I have opened up a graver difficulty. We cannot now be sure that we have sampled all the properties of the natural objects we are studying. We must expect these objects to have properties which we have not observed or, what is the same thing, to which we have paid no attention. And we cannot expect these properties also to be consequences of a theory which has taken no account of them, and to be displayed by a model conceived in ignorance of them. This is a deeper criticism of the inductive method than those which are commonly made.

The aim of the inductive method is to reduce the description of the universe to a chain of deductions from a finite set of axioms. If this aim is to be reasonable, then all the properties of a natural object must flow from some set of defining properties. What makes an object unique also must make it behave precisely as it does. All the properties of iron must flow from its atomic structure; and all the properties of my dog must flow from a set of defining properties, on which the whole dog is to be, as it were, an elaborate tautology. I do not think that we can have any confidence that this is a possible programme. And I am quite as much in doubt of its application to iron as to my dog. For we must base the definition of either class on those properties which are sampled. These may well suffice to make the class unique; but we cannot assume that they ever imply all its properties. The discovery of radioactivity, or of the black swans of Australia, should make us wary of generalising about *all* the properties of a class.

I should add that any deductive system in mathematics also contains a regress of this kind. Gödel has shown that it will contain theorems which do not conflict with its axioms, yet which cannot be deduced from them. Such theorems are analogous to properties of a natural class which do not flow from its defining properties. I have remarked that we know in practice, from the sampling procedure, that it is rash to speak of all the properties of a class. Now Gödel's result warns us that it may be rash even in theory. I say 'may be rash' and not 'is,' because Gödel's result holds for mathematical systems; it requires, roughly, that the system shall have available an infinity of numbers. But I am now not convinced that this is a demand that we need make among the axioms of a natural science; and I therefore do not press the analogy further.

The Search for Elements

I have been speaking so far as if the scientist who wants to make a theory has a task no more difficult than Euclid when he wanted to draw up a set of axioms. But the world is not so simple. Euclid's axioms were really simple experiences in geometry; that is why for so long they were thought to be self-evident. When Euclid defined a point and a line, he was in no doubt how his reader would picture them. It is only in modern times that perverse mathematicians have remarked that it works equally well to make these words mean the opposite of what Euclid meant by them. But the natural scientist has never been in Euclid's happy state of simplicity. From early times, he has been aware that the entities which underlie any axiomatic treatment of nature are not at all immediate to the senses. How on earth did anyone ever come to think of

atoms? Or of genes? How did anyone think of chemical structure?

I have never seen these questions put by philosophers of science. Yet they seem to me the fundamental questions to be asked of scientific method. Here is nature, a jumbled puzzle of substances. They all turn out to be assembled from 92 elementary substances. How did anyone get on to that particular key to the puzzle, or rather to those particular pieces in the jigsaw—and before that to the notion that it is a jigsaw?

I think that the key to these questions lies in the word 'puzzle.' From the outset, the Greek mathematicians and the Greek atomists approached nature with the notion that there is something to be learnt: she has a meaning. This belief was largely lost in the Dark Ages, which saw matter as a perpetual accident, kept in place from moment to moment by a new act of grace. Natural science did not flourish again until men like Alberti and Leonardo were ravaged by a new hunger for meaning. Like the Greeks, they were convinced that nature has a message. What we have been doing ever since is to look for the code.

I use the word 'code' designedly and literally. It was Leibnitz who likened the unravelling of nature by science to the reading of a cryptogram. I am not sure that he himself saw how powerful and exact this analogy is. Take any of the practical examples which I have quoted. From the seventeenth century, apothecaries knew that if you treat common salt with oil of vitriol, you make spirits of salt and that aid to digestion which, in their enthusiasm for Dr. Glauber, they called *sal mirabile*. We should now write the process

$$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl.$$

This statement is precisely the result of breaking down my sentence about making Glauber's salts, and a thousand other sentences for chemical reactions, into the elements of the code. We break it down into code letters: the word 'elements' and the word 'letters' are both exact descriptions.

Breaking the Code

Now go on to ask of the code why these letters are associated. Why does S so often go with O_4? Why does the letter H move about in so many of these messages? You are well on the way to another stop in de-coding: the counting of the relative frequencies of letters and of groups of letters. This count directly gives the theory of valency.

Go further. Join to your count a like process carried out on sentences in which physicists record their experiments. Put it that these valencies describe a structure; the structure of what we shall call atoms. The theory you now reach gives each atom a nucleus with electrons arranged round it in shells. The atoms are the letters S and O and H and the like, and you are doing nothing else than to break them down in turn. The alphabet of the new code no longer consists of 92 letters or elements, but only of two; a stroke / and an *x*, say. The stroke is the electron, and the number of strokes which you string out for each letter is characteristic of it: it is the atomic number of the element. The *x* at this stage is still an unknown and variable component, and it would be more just to write it frankly as a question mark. But in fact, in the last twenty years this stage has already been passed, and we can de-code the variable *x* into constituent symbols to make the message clear. These symbols are a dash – for the proton and a dot . for the neutron.

In this symbolism, we have broken down the letters of our code message into three constituents. They now read –/ for H, –.–.–.–.–.–.–.–./////// for O, and so on. When we have found this code, we see from the complete table (which includes the isotopes) that the number of dashes – is always equal to the number of strokes / so long as we stick to the un-ionised state of the atoms. We therefore discard the strokes as redundant, as nuclear theory in fact does, and we are left with the dots . and the dashes –. We write – for H, –.–.–.–.–.–.–.– for O, and so on.

You are so familiar with the facts which I have developed that to read them as a code may seem an artifice. Even as an artifice, I ought to remind you, it is powerful; Morse made telegraphy possible precisely because he grasped its power. But it is not an artifice. It is the fundamental approach of the scientist to the

problems set by nature. Modern chemistry derives from the periodic table, and that, I insist, is the discovery of the code in which nature writes the messages which we call chemical processes. What was the state of chemistry when the reaction for making Glauber's salts could only be described in words? When Humphry Davy showed that muriatic acid is H and Cl, he was breaking down the code in which nature has written all her sentences about it. Until the code was broken, chemistry was simply incoherent.

Most Informative Messages

The process of building a scientific system is an awkward one, in which it is much clearer what not to do than what is done. Even this morning I have had to spend time in such negative preliminaries. There is in fact only one positive procedure to be laid down. It is to treat the processes of nature as messages, and to look for the code which shall make them most meaningful or (what in this context is the same thing) most informative.

The Information in Nature

The brunt of my procedure is carried by the demand that the code shall make the messages as informative as possible. It is again characteristic of the awkwardness with which scientific procedure is treated that this demand is usually made in its negative form. Ockham did not tell us what to do but what not to do: we were not to multiply hypotheses. But consider two alternative theories to account for a series of experiments. If the experiments are read as messages on the symbols and axioms of the two theories, then they have in each case a content of information of the form

$$-\Sigma p \quad \log p,$$

where the p's are the probabilities that the symbols occur in their places by chance. The demand that we shall maximise their information content is therefore identical with the demand that we shall choose the less restrictive theory, that is the theory in which the symbols have more free choices for their occurrence or behaviour. And this is exactly Ockham's razor.

In summary then our procedure is this. We regard nature as composed of processes (and not of single objects or events). We regard the sentences which describe these processes as written in code. The scientific procedure is to break down the code into its constituent symbols and their laws of arrangement. So far, this is essentially the procedure for setting up an axiomatic system. But we add to it the requirement that *the code is to make nature as meaningful as possible*. That is: science is formally the search for that code which shall maximise the information content of the messages which record the processes of nature.

Both observation and description are limited in their fineness, and this sets a limit to the processs of de-coding. We can liken this to the presence of a basic level of noise under the message. We ourselves provide a grosser element of random noise in practice by our experimental errors. But these limitations apart, we assume that nature writes her messages free from noise: nothing in her processes is arbitrary. And nothing in her processes is meaningless; if we could only read them, her messages are everywhere dense with information.

These assumptions incidentally dispose of the difficulty, which has troubled logicians since the time of Laplace, that no experiment seems to add much to the probability, or I prefer to say the assurance, with which we can entertain a scientific theory. On the contrary, a good experiment is a challenge to nature to opt between one of two messages. Think of the great critical experiments of history: the apocryphal experiment which Galileo is supposed to have made from the tower of Pisa, the discovery of Neptune, the interference of light, the Michelson and Morley experiment, the work of Mendel, the charting of black body radiation, the eclipse of 1919, the atomic pile, the search for Yukawa's mesons. They were as decisive as the discovery in a crossword that 'bezique' crosses 'syzygy' at the right point—a discovery whose information content we can calculate, and show to be large. On the interpretation of the scientific process which I am putting forward, the analogy with the crossword is indeed close, for there too the clues are written in code. What is more important,

we see that there is no distinction (such as Collingwood imagined) between the physical sciences and those interlocking puzzle sciences like geology and palæontology and archæology.

The Code in Time

There is one oddity which will have struck you already. A code message is a linear arrangement of its symbols. It offers therefore only one dimension of structure ; and even the simple chemical compounds and their atoms which I have presented in code do not fit well into this. Is it really sensible to speak of a code when we want to symbolise, not the mere formula for salt, but its crystal structure ?

We must here beware of a confusion. What I have called a code sentence or message does not describe an object or an event : it does not describe a fixed structure. Such objects or events, such structures, are to be incorporated in the symbols themselves, and the internal arrangement of parts in a code symbol or group of symbols can be given as many dimensions as we find necessary. The code groups have a function space of their own. *What the message represents is always a process.* It is a sentence which summarises an experiment. That indeed has a dimension imposed on it : and the dimension is time. The formula which describes how you make Glauber salts says what you do first and what happens then. This is what I have called the causal structure, in its widest meaning ; and it underlies our code. The messages of nature have to be read in the direction of time which we experience.

This is a critical function of experiment. If we are only given a record of the past, we can order it on a rational theory. But we cannot tell whether in that theory time should run one way or the other, by anything within the record alone. The record might have been written backwards, as a book of code messages can be written and read backwards. What we must contribute is the decision which way the record shall read. We cannot make that decision without adding at least one experiment of our own to the record. This experiment has to fix the direction which nature imposes on living beings, as rectifiers of time.

Limitations of the Method

I have presented an experiment as a message ; and a theory as a code, ordered by time, which is to read in the record of experiments the most of information. This puts the axiomatic method in its most powerful form. But it cannot make the method all-powerful. We have no reason to suppose that it is so.

The limitations of the axiomatic method lie plain in the procedure of de-coding. We break the sentence into words, the word into letters, the letter into Morse—and so on for so long as we choose. But that apparently is what we must choose ; we cannot escape the piecemeal structure of language. Language is made to give information, and gives it in what information theory tartly calls ' bits.' This is therefore the way we get information from one another. But it also constrains us to look for knowledge in nature by the same process of taking her to pieces. For we do not analyse experiments ; we de-code the sentences which record them.

It is today familiar that the fine behaviour of matter is ill described by metaphors such as ' wave ' and ' particle ' which we carry from the world of gross behaviour. Every metaphor is too tempting ; it drags its context with it ; we cannot resist pushing it beyond its relevance, to ask ' particle of what ? ' and ' wave in what ? ' This difficulty is familiar. But the difficulty which I now raise is more radical. I am questioning the application to nature of the bit-by-bit structure of language itself.

With this question I must leave you. I do not pretend to know the answer to it ; no one does. Yet it has already an influence in science. The growing scope of field theories is one sign of that influence. Another is the formulation of those powerful grand laws which Whittaker calls Postulates of Impotence, such as the principle of relativity and the principle that perpetual motion is impossible. In genetics and elsewhere in biology, the piecemeal models begin to look very bare. And it is plain that quantum theory has long been a search for a description of events which is not written in dots and dashes.

These are transformations which scientists will reach for themselves. In

sum, they may make a major transformation of scientific method. But I end with them for another reason. The method of atomic models, the search for codes, has won great success for science. But it has left it helpless to contribute to those experiences whose meaning is not assembled from pieces. A work of music is not a succession of notes, but science, like the music-writer, is trained to see it so. This is what put Goethe and Blake in a rage with Newton. Concepts like honour and beauty are not unreal; they give order to a field of behaviour just as firmly as do concepts like momentum and world-line. But they are not atomic concepts; they can neither be taken to pieces nor put together. They do not fit well into language. No one has discovered how they can be handled. But if science moves away from particulate models, it may be taking a step towards that discovery.

My subject has been classical, and many other writers on it have stimulated me to think further. I should like to acknowledge two who have done so particularly; they are Donald Williams and D. M. MacKay.

THE HISTORY OF AFFORESTATION IN NORTHERN IRELAND[1]

Address by

J. PIMLOTT, O.B.E.

In prehistoric times Ireland was a country of forests. The evidence is provided by the large quantities of well-preserved logs and stumps found in her peat bogs. These are mostly pine and oak, though the remains of birch, alder and willow are widespread. It is not unusual to find two or three layers of timber showing how one forest succeeded another as climatic conditions changed down the centuries.

From earliest historical times, the greater part of Ireland was covered with primeval bogs and forests. It was inhabited by small self-governing Celtic clans, each with its own mutually recognised territory, and organised into loose and constantly shifting federations. The clans lived by herding, hunting and raiding; their wealth was counted according to the numbers of cattle they grazed in the forests and clearings; while in times of adversity the forests gave them a refuge from their enemies. They indulged little in cultivation of the soil and although they cut wood at will for their fires and the construction of their dwellings, their numbers were too small for this to have much effect on the extent of the forests. At this period of history, in fact, the needs of the forest and its inhabitants were in harmony; the existence of the forest was not an obstacle to their way of life but, on the contrary, a basic condition of it.

The first hint of a fundamental change came with the Anglo-Norman occupation beginning in the twelfth century and reaching its zenith about the end of the thirteenth century. Such of the native population as were not absorbed in the Norman settlements were driven into the hinterland, which tended to become more and more a succession of forest fastnesses. The Normans did, it is true, have a strict code of forest laws, but their primary object was the protection not of the forest itself but of the game that inhabited it. The forest became an area 'privileged for wild beasts and fowls of forest chase and warren, to nest and abide in, in the safe protection of the King, for his princely delight and pleasure.'

An indication of the state of the country at the end of the thirteenth century is contained in a statute of Edward I enacted in 1296; 'the King's highways are in places so overgrown with wood and so thick and difficult that even a foot passenger can hardly pass. Upon which it is ordained that every Lord of a wood, through which the highway was anciently, shall clear a passage where the way ought to be.' But the wars of the Bruces which followed within a few years nullified any effectiveness that this edict may have had.

Thus immense woodland areas still survived in Ireland even after the Anglo-Norman occupation. The first big step towards their reduction was the adoption by the Tudor sovereigns of a resolute policy towards the 'Irish enemy.' By hindering the deployment of the English forces, providing cover for flank attacks and offering a secure retreat after an engagement, the forests were of the greatest assistance to the Irish in the guerilla form of warfare they were obliged to adopt. It had become proverbial that the Irish would never be tamed while the leaves were on the trees, and the Tudor sovereigns responded by a policy of systematic clearance of large tracts of the country. By the end of Elizabeth's reign the central plain of Ireland was reported as nearly destitute of trees. The 'English Pale'—a relatively small bridge-head centred on Dublin, where direct English

[1] Chairman's Address to Forestry Sub-Section, delivered in Belfast, September 4, 1952.

rule had survived since the Norman invasion—had of course been denuded of trees for centuries. So much so in fact that Henry VIII found it necessary in 1534 to issue an ordinance directing every husbandman to plant twelve ash trees within the confines of his farm.

The Northern Province was the last to fall; but by 1608 the power of the last native chieftain was broken, and in 1609 began the settlement of Ulster with English and Scottish colonists—the so-called Plantation of Ulster. Far from being a plantation in any silvicultural sense, this operation involved a very considerable clearance of wooded lands for agricultural use, and this process went on as the settlements extended. The rebellion and civil war which began in 1641 and ended with the Cromwellian Settlement of 1652 brought further denudation of the forests.

The destruction of the woods, begun as a deliberate military policy and continued by the accidents of war, was accelerated by the circumstances of peace. As grants of land were made at the will of the sovereign of the time and for political reasons, there had been little security of tenure of land since the Tudors began their reconquest of Ireland. With the Stuart Plantations, the Cromwellian Settlement, the Restoration of 1660, and the Revolution of 1689, all in so short a space of time, the seventeenth century was characterised by an even greater insecurity than the sixteenth. It was an era of confiscation and under these circumstances owners of estates tended to make as much hay as possible while the sun shone. The bases of many great fortunes were laid at this time on the exploitation of the woods. The manufacture of pipe-staves and the development of the iron-smelting industry, using local ore and wood fuel, were responsible for vast clearances of woodland. Richard Boyle, the Earl of Cork, was reputed to have made £100,000 from his ironworks, and the sale of timber must have brought him nearly as much again. Whole shiploads of pipe-staves were exported from Munster, to the great profit of the owners and the great destruction of the woods, which proceeded at such a rate that the want of fuel, formerly abundant, began to make itself felt. A diarist of the period writing in his Journal about the year 1682, remarks on the consequent substitution in many areas of turf for wood firing.

This process of reckless exploitation went on till well into the eighteenth century. Swift wrote 'there is not another example in Europe of such a prodigious quantity of excellent timber cut down in so short a time with so little advantage to the country either in shipping or building'; while Arthur Young in the journal of his 'Tour in Ireland' (1776–79) reported that 'the greatest part of the country continues to exhibit a naked, bleak, dreary view for want of wood, which has been destroyed for a century past with reckless prodigality, and still continues to be cut and wasted as if it were not worth the cultivation.'

Although unchecked, the exploitation had not gone unrecognised or even unchallenged. A considerable clearance of woodlands was, of course, inevitable as the natural consequence of the social transformation which followed the effective assertion of English power. It was not only natural, but desirable, that large districts of lowland forest should be turned over to productive agriculture to support a larger population on a higher standard of living. But, as has been said, the process went far beyond this, and the Irish Statute Book from the Restoration to the end of the eighteenth century contains many measures which had for their object the encouragement of planting and the replacing of timber in those districts from which it had disappeared.

An Act of William III of 1698 recognised in its preamble the causes of deforestation: 'Forasmuch as by the late rebellion in the Kingdom and the several ironworks formerly here, the timber is utterly destroyed, so as that at present there is not sufficient for repairing the houses destroyed, much less a prospect of building and improving in after times unless some means be used for the planting and increase of timber trees.' The remedial means adopted were: to require all freeholders, and tenants with ten years' or more unexpired lease, to plant every year for thirty-one years ten trees of five years' growth; owners of ironworks were to plant 500 such trees annually so

long as their ironworks were in operation. In addition, every occupier of above 500 Irish acres was required to plant at least one acre and preserve it as a plantation for at least twenty years, and a total of 260,000 trees were to be planted annually for thirty-one years by persons or corporations seized of lands of inheritance, the number for each county being laid down by the Act and to be apportioned inside each county by the Grand Juries at each summer Assizes. Tenants planting under this enactment were given ownership of one-third (later increased to one-half) of all timber planted by them.

All these Acts were in turn repealed in 1776, as having proved ineffective, by an Act of George III which gave to tenants the right to the full value of all trees planted by them. It is doubtful whether this Act was any more effective than its predecessors, but it did have the merit of recognising that the existing tenancy laws were a major obstacle to planting. Throughout most of the country (though the Ulster tenant right system prevalent in the North was more favourable to the tenant) the majority of tenancies were terminable at will and any tenant's improvements remained the property of the landlord without any compensation being due to the tenant. Thus the security necessary to long-term investment such as tree-planting was completely absent. The Act remedied this, but it did not meet the other basic condition of investment—that there should be surplus resources to invest; and in fact the majority of Irish tenants lived only at subsistence level, with no surplus resources available to meet the cost of planting trees.

The various Acts referred to were not, of course, isolated phenomena; they sprang from a growing public awareness that woodlands were a desirable source of wealth and amenity in a country. The publication of John Evelyn's '*Sylva*' in 1664 marked an important stage in the growth of this awareness, which became widespread—at least in the ruling circles—during the eighteenth century. This was the beginning of the period of the great improver landlords, who included arboriculture among their other estate interests. The Royal Dublin Society, for instance, whose members were of this class, was founded in 1731. From the start it displayed much interest in planting and during the period from 1741 to 1808 it offered premiums for planting and for the development of forest nurseries. The amount of the premiums and the conditions varied from time to time. It is interesting to note that in 1800 three premiums of £100 each were offered 'for planting by contract the greatest quantity of ground not less than 40 acres, and three of £50 to the next greatest quantity of ground not less than 20 acres.' The nurseryman who did the planting on contract was required to 'furnish and plant in each acre 8,000 trees at the least' and to maintain the plantation so that at the end of three years there were still 8,000 trees to the acre of which 3,000 were to be either oak or larch in each case. Nurseries were assisted either by grants per acre or premiums of 4*s*. per 1,000 for trees sold—the species being specified. There is no doubt the system, on which the Society expended £20,000, did much to arouse interest and create a spirit of emulation amongst estate owners, though it did not lead to the establishment of any really large plantations.

For a period of about 150 years from 1700 to 1850 many owners of estates in Ireland carried out planting in their demesnes and in outlying areas. It was, indeed, not uncommon for an expert, who might well be described as a 'landscape forester,' to be engaged, and he not only planned the portions of the demesne to be planted, but also supervised the planting operations. The planning had regard mainly to scenery and amenities and little attention was paid to the commercial aspect. Nevertheless, it was the timber from these woods that made such a valuable contribution to the National need during the two world wars. There has been little new planting during the last 100 years, but on many demesnes a certain amount of cleared woodland has been replanted mainly with conifers.

The statistical surveys published by the Royal Dublin Society about 1800 contain many references to the state of the woodlands in the respective counties and make favourable mention of the planting operations carried out by individual estate

owners. The Survey for County Tyrone published in 1802 explains in much detail the planting methods adopted on the estate of Lord Mountjoy. It is of interest to note that such recent developments as ploughing, turf planting, contour draining and the sowing of broom in patches amongst planted trees were routine practice on this estate 150 years ago. The Survey for County Londonderry refers to the 'barbarous havock' caused by the destruction of woodlands. Among the causes for this widespread destruction the writer included the demand for charcoal for the smelting of lead and iron.

During the period from 1866 to 1907 loans to the total amount of £33,000 were granted by the Government for tree planting. The interest was excessive for the object in view except in those cases where loans were granted for the direct purpose of providing employment to relieve distress.

In 1851, the first year for which official statistics are available, the area of woodland in all Ireland was a little over 300,000 acres and, while there was some fluctuation from year to year, the total for 1907 was approximately the same. This was equivalent to 1·5 per cent. of the total land area.

In 1890 the Government, without obtaining expert advice, acquired as an experiment an estate of 1,000 acres at Knockboy on the extreme west coast and began to plant it with trees. In 1891 the area was handed over to the newly formed Congested Districts Board—which may perhaps be described as a kind of prototype Tennessee Valley Authority with the task of restoring a measure of prosperity to the desolate regions of the West. The Board struggled on with the experiment for ten years, but the site was too exposed and sterile and failure was eventually complete. This unfortunate experiment cost the State £10,500 and without doubt it stifled further interest in forestry development by the Congested Districts Board.

A fundamental change in land ownership and tenure took place with the enactment of the Irish Land Purchase Acts of 1885, 1891 and 1903. The purpose of these Acts was to enable the sitting tenants to buy the holdings they had hitherto rented so insecurely. As it happened, this legislation—especially the Act of 1903—pressed particularly hardly on the woodlands. The method of transfer of ownership was for a purchasing authority, the Estates Commissioners, to buy estates from the existing landlords and to resell them piecemeal to the tenants by means of a long-term, State-guaranteed mortgage. The landlord normally retained his demesne, but usually preferred to sell outright all his outlying properties, even if they had been directly occupied by himself. Unfortunately for the welfare of the wooded lands, the financial arrangements of this legislation were such that the Estates Commissioners were in effect obliged to resell immediately all their purchases. Not able themselves to undertake the management of woodlands, they could only offer to buy the wooded part of an estate if they could at once recoup their expenditure by resale, either to an authorised forestry department for dedication or to a timber merchant for exploitation. Thus a whole series of factors combined to favour the denudation of the remaining woodlands and to discourage replanting. The Estates Commissioners found the existence of woodlands an embarrassment to the successful negotiation of sales ; the old landlords were stimulated to realise while they yet could the cash value of timber in their outlying woods ; the new peasant landowners were for the most part poor, and the felling of trees on their holding at once provided ready cash. The legal formalities of transfer of ownership frequently took a considerable time and many cases were reported of both the old and the new owners indulging in competitive exploitation during the period of doubtful ownership. The process of denudation was helped by an exceptional storm in 1903 which blew down an immense number of the trees which had been planted a hundred years previously by the improver landlords. Portable saw mills sprang up like mushrooms and travelled round the country clearing one wood after another ; English and Scottish timber merchants were attracted to Ireland by the plentiful supply and the ports of Ireland became chock-a-block with native timber leaving the country. The Department of Agriculture already had

the requisite powers to act as a forest authority ; all it lacked were the funds to inaugurate a comprehensive scheme of development, and these could have been provided by a Government policy decision. Given funds, the Department could have afforested extensive blocks of upland and maintained under good management many of the lowland woods which were being stripped.

All these cogent considerations, and many more, were brought to the notice of the Government of the day by a Departmental Committee of Enquiry which reported in 1908. The case presented was convincing, and as a result the Department of Agriculture was provided with funds which made it possible to begin the acquisition of land. However, it took the shortages of timber and shipping space which were felt so keenly during the First World War to drive home the lesson that a national policy of forest conservation was one of the keys to national survival.

The war gave birth to the Acland Report and through it to the Forestry Commission, which included Ireland in its sphere until the Northern Ireland and Free State Governments were set up in 1921 and assumed control over their own forestry programmes.

Eighteen years previously, however, the Department of Agriculture had taken the first real official step towards the development of forestry in Ireland. It appointed as a forestry inspector, Mr. A. C. Forbes, a gentleman of high standing in his profession, and it acquired an estate of 550 acres at Avondale, County Wicklow. A forestry school was inaugurated there in the autumn of 1904 for the purpose of ' training young men as working foresters and woodmen for employment in Ireland.' A three years' course was planned with the object of ' so combining theory with practice that the men there trained can adapt themselves to the varied conditions under which they will probably have to work in the future.'

An important series of plots was laid down for the purpose of obtaining information on the commercial value of all species which had hitherto shown any indication of proving useful in Ireland. There were 91 plots of about one acre each in size and the more important species were planted both pure and in mixture with other trees. An arboretum was established containing 150 species and a pinetum comprising 101 species.

Up to this point consideration has been given to afforestation in Ireland as a whole. The Government of Northern Ireland was established in 1921 and became the forest authority and it is now proposed to deal more particularly with conditions in Northern Ireland and to describe the developments which have taken place during the last thirty years.

The soil and climate are very suitable for the growing of spruces and, under favourable conditions, ash, beech and oak can be grown equally well, while there are a few centres on which the soil is particularly adapted to growing larch. The number of wooded demesnes is relatively much fewer than in England and in many districts the absence of hedgerow timber is very noticeable. The total area of land on which trees are growing is stated officially as 54,000 acres or 1·6 per cent. of the total land area. Apart from the wooded areas owned by the Government amounting to approximately 32,000 acres, the condition of the woodlands is often far from satisfactory because of the thinning out and removal of the best and most valuable timber from time to time. It is unfortunately the case that economic conditions have prevented many owners of demesnes from managing and maintaining their woods in the best state for the production of high-class commercial timber, and most of the woods outside demesnes are in an even less satisfactory condition.

Grants to assist private owners have been offered on much the same lines as by the Forestry Commission but they have not been availed of to any great extent.

By 1921 the Department of Agriculture in Dublin had acquired 1,025 acres at three centres in Northern Ireland and the Forestry Commissioners had leased almost 3,000 acres on the estate of the Duke of Abercorn at Baronscourt, County Tyrone. All this land was handed over to the Ministry of Agriculture which commenced its forestry operations with one inspector and about twenty-five men.

Today the Ministry holds over 56,000 acres, of which 32,000 have been planted, and it employs a staff of eight inspectors and almost 800 men.

In the early years it was the policy of the Ministry to acquire blocks of not less than from 300 to 400 acres, and at a price not exceeeing £4 per acre free of all charges when the land was purchased, or at a rent not exceeding 4*s*. per acre when the land was leased. These limitations, particularly that of price, prevented the acquisition of many blocks of land very suitable for afforestation. During that period purchases were mainly confined to the poorer hill grazings, and the willingness of the owners to sell was governed chiefly by the profit then being obtained from the grazing of hill sheep ; as sheep profits declined, the Ministry's purchases increased. It may be noted that in Northern Ireland there has not been the same clash of interests as in Great Britain between hill sheep farmers and the forestry authorities. A certain number of objections have been raised to diverting land from food production to the growing of trees, but in the main the transfer of land from one purpose to the other has been carried through smoothly. At the same time, it must not be forgotten that hill sheep farmers have a useful part to play in the farming economy of Northern Ireland as lowland farmers are largely dependent upon cast ewes from the hills for their breeding flocks. The time might come when the reservoir of breeding stock maintained on the hills would be unduly depleted if forestry acquisitions were pursued irrespective of all other interests, but the administrative integration of forestry and agriculture under one Ministry makes the possibility remote.

Since the end of the war the limit of £4 per acre for purchased land has been abandoned and higher prices are now paid when they are justified by the conditions. This had led to a marked increase in the acreage acquired, and, wherever possible, to the purchase of numerous blocks of land in close proximity. In Northern Ireland it is not possible to acquire large estates as is the case in Great Britain. Here all the farms have been acquired by the tenants under one or other of the Land Acts, and purchases by the Ministry are confined to distinct and relatively small areas of hill land, to single farms and to demesnes. If, therefore, a number of units can be acquired in close proximity, it is possible to effect considerable economies in working operations and in supervision.

An interesting development of forestry in Northern Ireland has been the number of demesnes which have been purchased. Most of these contained considerable stands of timber ; when this was valued at market price it enabled the Ministry to make an offer acceptable to the owner and which left the land at a price that was economic for forestry purposes. In most demesnes the timbered land was carrying hardwoods and it was usually suitable for their growth. It was customary to clear fell all mature timber and replant with hardwoods. That was not always possible because of the heavy undergrowth of laurels or rhododendrons, and in such cases the first crop had to be shade-bearing conifers such as Douglas fir or spruce. A high proportion of the best land which has been planted by the Ministry lies within the demesnes which it has acquired.

Out of the total of 56,000 acres in the hands of the Ministry, about 11,000 acres are presently regarded as unplantable, mainly because of altitude or the nature of the land. Little planting has been done at altitudes exceeding 1,000 feet, and there are some areas of deep, wet peat. In recent years progress has been made in planting technique and some land which was regarded as useless when purchased is now carrying crops of fair promise. Further developments in planting technique may still further reduce the proportion of unplantable land.

The land held on lease comprises almost 7,000 acres, nearly half of which is on the Baronscourt estate in County Tyrone. Most of the remainder is situated in the Sperrin Mountains in the catchment area of the water supply for the city of Londonderry. The official policy favours purchase rather than leasing of land for afforestation.

The forestry operations of the Ministry of Agriculture have expanded steadily since 1921. As more and more land has been acquired, increased planning and

supervision have necessitated an increase in the inspectorial staff. This has been accentuated by the many relatively small centres as compared with Great Britain. The staff of workers is increasing yearly because more forests are reaching the thinning stage and more roads are being made to facilitate the extraction of timber. The nursery work tends to increase also because of the larger demands for trees from farmers. This is a service which was commenced in order to encourage the planting of shelter belts and clumps, particularly near the farm dwellings. For this purpose trees of certain species are supplied at reduced rates in minimum quantities of 1,000. The Ministry raises practically all the trees required both for this purpose and for its own planting programme.

Prior to 1928, the average rate of State planting was about 500 acres per annum, for the succeeding 19 years it averaged about 1,000 acres and since 1948 fully 2,000 acres have been planted each year. It is expected that the present rate of planting will be maintained, and if that can be done some areas at least of this comparatively treeless country will soon be well-wooded.

CORRESPONDING SOCIETIES

BELFAST, 1952

THE Conference of Delegates of Corresponding Societies was given new status during the Association's Annual Meeting at Belfast. On the first day of the Meeting, September 3, the General Committee approved decisions by the Council that the Conference of Delegates should in future be known as the Assembly of Corresponding Societies and that the symbol X should be used by it on all occasions comparable to those when letters were used to denote Sections of the Association. At this meeting of the General Committee, Mr. J. A. S. Stendall, O.B.E., M.Sc., became first President of the Assembly, and Mr. Frank Edwards first Recorder, on receiving badges of office from H.R.H. the Duke of Edinburgh.

At 2 P.M. on Thursday, September 4, the first meeting of the new Assembly was held in the Lecture Hall of the Municipal Museum, when the President delivered his address, 'Problems and Responsibilities.' This gave an outline of the history and work of the Belfast Naturalists' Field Club and a call for action by other local societies. Mr. Stendall also dealt with the constant need for local surveys and the valuable part that the Museum and the local Societies could play in the preservation of nature and amenities and in the stimulation of public interest in such things. A promising discussion was inaugurated but the meeting was brought to a close so that delegates might attend the Government Reception at Stormont.

Practical work was to some extent continued on the main theme on the Friday afternoon (September 5) when the members of the Assembly visited Antrim Town and the delightful country around Lough Neagh. On the return journey a halt was made at Belfast Municipal Airport where the members made a tour of the airfield and the control offices.

The Annual Luncheon was held on Monday, September 8, and the occasion was lent greater distinction by the presence of the Earl and Countess of Antrim, Lady Powerscourt, Lord Raglan, Mr. and Mrs. Dennis Hanna and Mr. Councillor Tougher (Chairman of the Museums and Art Galleries Committee of the Corporation) and Mrs. Tougher. Dr. W. E. Swinton (President-elect for 1953 Assembly) spoke on the opportunities that were now afforded the Assembly and outlined some necessary steps for their fulfilment. Mr. Stendall and Councillor Tougher briefly commented upon aspects of this address.

After luncheon, the party adjourned to the Art Gallery where the Earl of Antrim addressed a large audience on the work of the National Trust of Ireland of which he is President. His talk was illustrated by a fine collection of photographs. The meeting was honoured by the attendance of Professor A. V. Hill, C.H., F.R.S., President of the Association.

The afternoon session was continued by Mr. Hanna who discussed 'The Architectural Heritage of Ulster,' illustrating his remarks also by excellent photographs. The afternoon's proceedings were notable for the keenness of the discussion and for the size of the audience, which was undoubtedly greater than would have been the case if attendance had been restricted to delegates.

In the early evening a cocktail party was held in the Art Gallery at which the principal officers of the Association, and the Lord Mayor, Aldermen and Councillors of the City of Belfast were present. This was pre-eminently a social occasion but there were ample opportunities for informal discussions.

Members of the Assembly were especially invited and warmly welcomed on the evening of Tuesday, September 9, at the conversazione arranged for members of the Association by the Belfast Naturalists' Field Club in the Whitla Hall of the Methodist College.

PROBLEMS AND RESPONSIBILITIES

Address by

J. A. S. STENDALL, O.B.E.

PRESIDENT OF THE ASSEMBLY OF CORRESPONDING SOCIETIES

At the outset of this Address permit me to say how much I appreciate the honour accorded by the Council of the British Association in entrusting the Presidency of the Conference of Delegates to me, at this the fourth meeting of the Association to be held in the City of Belfast.

Half a century has gone by since last the British Association met here ; years marked by a wealth of scientific achievement, though marred by international strife and economic difficulties, which have meant a reorientation of the lives of men. We live in a more materialistic age now than then ; an age of difficulty no less for scientists than for any other body of men or women. Changes are essential in many spheres of life ; without them there is no progress and I have taken the opportunity afforded by this Address to place before you my thoughts concerning the well-being of local Societies, together with the part they might play individually or collectively in the safeguarding and recording of our natural heritage and with suggestions as to the manner in which this Conference of Delegates could play a major part in the consideration of methods and the co-ordination of effort.

Perhaps I should explain that my life has been spent in Museum service—that of a Society's Museum and of a Local Government body—spread over a considerable number of years. It is thus that my activities can be said to have ranged over a multiplicity of subjects, but it is to the study of nature I am apt to turn. In consequence for the most part I shall instance Societies embracing natural history, yet I do not for a moment wish to infer that those dealing with other matters are not to be considered.

Before embarking on my main theme, however, I must say something as to the history of our Northern Ireland Societies, of the stalwarts who in days gone by performed great service on their behalf and were indeed ambassadors of the advancement of science.

The origin of the local Scientific Societies in Ireland is more or less similar to those formed elsewhere.

In the North, towards the close of the eighteenth century, members of the Belfast Reading Society were seriously considering the possibility of forming museum collections connected with natural history, the arts, and philosophy ; thus the seed of things to come was sown.

John Templeton, born in Belfast in 1766, one of the foremost pioneers of intellectual progress in his native town and a naturalist of repute in a much wider field, was a leading adherent to this enterprise, but unfortunately failing health precluded him from taking the active part in the proceedings he otherwise undoubtedly would have done. His beautifully illustrated *Journals* are in the Belfast Museum and Art Gallery ; a selection is now on temporary exhibition for members of the British Association to see.

Germination commenced in 1821, when Dr. James Drummond, along with seven colleagues, met in the town and decided on the formation of a Society for the cultivation of science in its various branches ; in particular for the investigation of the natural history and antiquities of Ireland. This, then called The Belfast Natural History Society, was the beginning of the now venerable Belfast Natural History and Philosophical Society, the addition to the title being made in 1842.

Maybe a Presidential Address should not be the place to refer to domestic details concerning this or any other Society, but certain items of historical

interest have been left on record which will at least help to enliven a more or less serious occasion. One concerns the very rigid rules laid down by the original members of the Belfast Natural History Society. Members had to give papers in rotation, with the subject announced two meetings prior to each event. Omission to declare a paper meant a fine of 1*s.* 3*d.*, a sum which was doubled should the member fail to carry out his obligation, but, owing to the number of threats of resignation by delinquents, this rule was modified in 1822.

The Society, having no regular home in its infancy, conceived the idea of erecting a building which would be adequate not only for its meetings, but to contain collections which then were steadily accumulating. Ultimately a site was secured in College Square North, adjacent both to the birthplace of William Thompson—afterwards Lord Kelvin—and to the school he attended. The two last-named buildings still stand, the former now being a cinema and the latter continuing as the Royal Belfast Academical Institution, numbering among its pupils today those who form a flourishing little Natural History Society.

In November 1831 the Society's new premises were opened—its Museum—the first actually to be built by voluntary subscription in Ireland. Additions were later made and today the building stands erect, still used as the headquarters of the old Society, but no longer as a museum.

In the course of its existence the Society has embraced within its membership many eminent scientists. Among these was William Thompson, the foremost Irish naturalist of his time, and author of *The Natural History of Ireland.* He was President of the Society for eight years and died suddenly in 1852, when in London on business connected with the visit of the British Association to Belfast later in that year.

Robert Patterson, F.R.S., was another prominent member—a foundation member in fact—eminent as author of many zoological works. For five years—from 1839 to 1844—he was a British Association Sectional Secretary.

Then there was Alexander Mitchell, the blind engineer who invented the screw-pile and was awarded the Telford Medal for this 'simple means of constructing a durable lighthouse in deep water in shifting sands.' Those of you who reached Belfast by sea would pass one of the earliest of Mitchell's lighthouses—known as the Pile Light—at the entrance to the channel leading to the city.

There were also Dr. Thomas Andrews, F.R.S., the well-known chemist, George C. Hyndman, the conchologist, Rev. Dr. Thomas Romney Robinson, famed for his labours at Armagh Observatory, Sir James Emerson Tennent, a man of many parts, and Thomas Workman, the arachnologist. These and others made up a goodly fellowship and gave lustre to the Society.

In 1910 the large and important collections contained in the Museum of the Society were transferred to the keeping of Belfast Corporation, and now are incorporated with those contained in the building in which we are now assembled.

This Society, even though it now lacks some of the virility of earlier times, maintains its place in the community and can look back with no little satisfaction on the part it has played in the advancement of science in Ireland.

The Belfast Naturalists' Field Club also is an old Society, having been formed in 1863, not really as a breakaway from its elder brother, but as a logical development therefrom.

It is recorded that 'In 1860 a few members of the Natural History and Philosophical Society organised a course of scientific lectures in Belfast under the Science and Art Department of South Kensington. Professor Jukes . . . was sent by the Department, and he delivered a series of lectures on geology to classes nearly four hundred strong. The Natural History and Philosophical Society was greatly encouraged by the interest shown and decided to continue the good work. Through the Science and Art Department it obtained the services of Ralph Tate of the School of Mines. . . . He conducted classes in Belfast and the neighbouring towns, in geology, zoology and botany, and . . . made a special feature of field work. . . .'

Tate had among his pupils a number who later became well known in Ulster

for their field investigations, one being Samuel Alexander Stewart, a trunkmaker in this city, who was responsible, along with Thomas H. Corry, for the production in 1888 of *A Flora of the North-East of Ireland*, which was the standard Flora—with supplements—until superseded by a second edition in 1938, edited by Dr. R. Lloyd Praeger and the Rev. W. R. Megaw. All these works were sponsored by the Field Club.

Later, Stewart became Curator of the Natural History and Philosophical Society's Museum, and one of the leading field botanists of his time. Ralph Tate, along with Stewart and several of his fellow pupils, now played a leading part in the formation of the Naturalists' Field Club, for the purpose of pursuing more energetic investigations in the field, and in the scientific interests of the common man.

Since 1863, until now, this Club has played no inconsiderable part in the investigation of the natural history and archaeology of the North of Ireland. It has been responsible for numerous important publications and produced many amateur scientists and archaeologists of outstanding ability—apart from Stewart. For example, Canon John Grainger, George C. Hyndman, Joseph Wright, William Gray, William Swanston, Nevin H. Foster, Robert J. Welch, and Robert Bell, to mention only a few. Canon Grainger accumulated a tremendous array of objects of archaeological and general interest connected with Ulster, which came to Belfast in 1891 as his bequest. These found a home in the City Museum, then in its infancy, and now form part of the exhibits to be seen within these walls. Hyndman was an outstanding conchologist and Joseph Wright one of the leading authorities in these isles on foraminifera ; his slides also are preserved here. William Gray, geologist and antiquary, was not only a man of great ability, but one of forceful character. He was largely responsible for Belfast adopting the Public Libraries Act in the eighties and thereby cleared the way for the provision, not only of a Municipal Library service, but of a Museum and Art Gallery service as well.

Gray also played a leading part in the preparation of a *Guide* to local natural history and antiquities, for use by members of the British Association at its Belfast meeting in 1874, and thus initiated an annual service which has proved of so much value to members of the Association right up to the present day.

The *Proceedings* of the Belfast Naturalists' Field Club for 1874–75 contains a reference to Gray's work in connexion with this *Guide*, which reads :

> 'You have all seen the Guide so recently issued by the Club, a work which is as yet unique. To Mr. Gray is due the honour of originating this work, and also the execution of a very considerable portion of it. This work has brought the name of the Belfast Field Club prominently before the naturalists of the kingdom, and our example will doubtless be followed by societies in other places when similarly circumstanced ; indeed I am given to understand that already steps have been taken in this direction in view of the forthcoming meeting of the British Association in Bristol.'

For the Belfast Meeting of the British Association in 1902, members of the Field Club were again responsible for a *Guide*, while one for the present occasion has been prepared under the direction of a Past President of the Club, who also is a member of the elder Society.

Swanston, along with Professor Lapworth, performed outstanding work on the correlation of the Ordovician and Silurian rocks of Co. Down with those of Scotland. Foster was an ornithologist of repute, later to take up the study of the terrestrial isopods, while Welch possessed an appetite for all things concerning nature, or antiquities, which was positively staggering. He was a reputable conchologist and a general collector of invertebrates. Professionally he was a commercial photographer and used his talents as such in the recording of the geological phenomena, of field antiquities and the scenic grandeur of Ireland as a whole—the north in particular. On his death in 1936 his great collection of negatives was acquired through the Field Club, and presented, together with his magnificent conchological collection, to this

Museum and Art Gallery, forming a fitting memorial to a remarkable man.

Of all men, one of the most unassuming must have been Robert Bell—shipyard riveter and field geologist. He literally hammered his way through life; he worked long hours and yet pursued his scientific work with unremitting enthusiasm. Many a museum collection in these islands has been enriched by the efforts of Robert Bell. He and Welch were as one in their efforts to help young folk, and were never happier than when in company with members of the Junior Division of the Field Club, either in the field or during indoor session.

This Junior Division, founded in 1911, is a strong offshoot of the Club and from its ranks have emerged many well-known field investigators of recent times. Happily most of these are active today, so I have no intention of particularising; if I succumbed to that temptation this Address would never end.

I must, however, mention one member of the Field Club, the doyen of Irish botanists, who happily is still with us. I refer, of course, to Dr. Robert Lloyd Praeger. By his work throughout every county in Ireland and by his voluminous writings thereon, our knowledge of plant distribution with its relationship to the elucidation of many scientific problems has indeed been enriched.

Affiliated to the Belfast Naturalists' Field Club are other Clubs throughout the Province—at Londonderry, Omagh, mid-Antrim (Ballymena), Newry, Rostrevor and The Route (Coleraine). Each is an independent body, making investigations in its own area, while co-operation is maintained by a frequent exchange of lecturers and by joint field meetings. Several school natural history bodies are associated with the Junior Division of the Belfast Club, while some of the country Clubs have their own Junior Sections as well.

The results of some recent field work carried out by members of the Belfast Naturalists' Field Club—Senior and Junior—can be seen in one of the galleries upstairs. There an exhibition has been specially arranged to illustrate the early stages of what promises to be an extensive survey of Crow Glen, a place within easy reach of the city.

It will be apparent that, on the whole, Northern Ireland is well provided with natural history societies, some having archaeology as a subsidiary interest, though there is a present-day tendency for natural history to be relegated to a subordinate position.

The trend of modern life is all against the production of the amateur scientific worker as of old—of men like those I have mentioned and those whom each delegate here assembled can either mention or recall. At the same time it is an undoubted fact that nature-study, coupled with that of the past, is still very much to the fore throughout the country today.

I suppose it is true to say that every local Scientific Society is composed of interested persons, but it is on the shoulders of the few that the well-being of the whole must fall. It always has been so to a greater or lesser extent, but today it would seem that in a much larger measure is there a lack of that wholehearted drive necessary for really useful progress, especially on the part of those upon whom the years have not yet begun to fall so heavily.

During the last decade or so—admittedly a most difficult time for us all—the publications of local Societies have tended to decline, due, to a large extent, to an alarming increase in the cost of printing. Thus many Societies are faced with a problem they find themselves unable easily to solve, for should subscription rates be raised there is a fear of losing members, and it is not always those who can afford to continue in membership who are best fitted by ability and inclination to follow up the good work accomplished in the past. That some Societies can and do even now manage to publish original work carried out by members is a tribute both to their strength and standing, but others are not so fortunate and thus there is a possibility of the loss of important records. This is a matter of consequence and if I venture to place before you suggestions which might go some way towards solving a problem that tends to become more and more difficult, I assure you I do so without any iconoclastic intent.

One suggestion is that there should be a pooling of effort in the issue of publications, and in this connexion it is interesting to read in *The South-Eastern Naturalist and Antiquary* for 1950—that excellent publication covering the activities of over seventy affiliated Societies in the London area—an editorial note, which reads: 'The Council is prepared to consider for publication papers delivered to affiliated Societies—the first accepted is included in this volume. . . .'

Similar publications to the *S.E.N.* exist in other parts of the country—for example *The Naturalist*, *The North-Western Naturalist*, *The Scottish Naturalist*, and, coming nearer home, *The Irish Naturalists' Journal*.

With the last named I have had close contact since its inception in 1925, when it followed the old *Irish Naturalist*, started in Dublin in 1892 by Dr. R. Lloyd Praeger and the late Professor G. H. Carpenter. Both Journals always have had the support of Irish local Scientific Societies and, until the revival of *The Ulster Journal of Archaeology*, a small amount of antiquarian material was carried in *I.N.J.*

If I may turn to home ground in order to illustrate the point I want to make and use *The Irish Naturalists' Journal* as my example, I can say that more and more do our Irish naturalists—north and south—depend upon it as a vehicle for the distribution of their scientific contributions. The majority of the Societies simply cannot afford to publish separately and, furthermore, if they did would they not dissipate energy which might otherwise be employed to the advantage of each individual body?

A modest fee is payable to *The Irish Naturalists' Journal* by affiliated Societies, but of recent times it has been found that instead of attempting publication themselves—excepting for annual reports—there is a tendency for Societies to subsidise this Journal by an amount each can afford, in return for publication services rendered. Thus not only is publication becoming centralised, there also is advantage in having a qualified editorial panel drawn from the area embraced, and, further, the time lag in publication affecting so many worthy scientific papers is greatly diminished—an extremely important point.

I suggest to you that in adopting this method of assisting hard-hit local Scientific Societies—whether they specialise in the teachings of nature, archaeology or in other subjects—the periodical acting as the vehicle itself benefits and becomes a living thing. How to bring a change of this kind would be a matter for consideration by a representative body, which—if I may again suggest—might well be the British Association for the Advancement of Science, working through its Conference of Delegates.

The amalgamation of Societies in populous areas is another matter which might well be ventilated. By amalgamation I do not mean outright absorption—that would be totally wrong—but the drawing together of bodies interested in science and kindred subjects in a manner whereby they can form a whole, yet be independent so far as is required to carry out their individual functions.

Advantages would be a pooling of resources, possibly the provision of a permanent home, and ease of administration which, among other things, would avoid the duplication of mailing lists with consequent economies. It is more than probable that some difficulties in formulating such a scheme would arise, but that is not a reason for stifling discussion of the problem.

Some Societies still maintain Museums and in such cases meetings of members are naturally held therein. Others are permitted to meet in rate-aided Museums and readily take advantage of the opportunity so to do. To my mind, when a Society has no permanent home and a rate-aided local Museum is available the latter should, if possible, lend itself to a mutual understanding whereby both may well benefit.

Permit me now to change from matters domestic and enter the natural scene in Northern Ireland, full as it is of beauty and interest.

That Northern Ireland possesses some of the finest scenery in these islands is an undoubted fact. The granite mass of the Mountains of Mourne in Co. Down—celebrated in song and story—are outstanding in their grandeur. Lough Neagh is the largest sheet of fresh water in Britain, and is only on the other side of the Belfast

Hills. It has a peculiar beauty of its own, with Slieve Gallion dominating the Co. Tyrone Mountains to the west, and the Sperrin Mountains of Co. Londonderry away northwards. The Antrim basaltic plateau stretches along the east, while southwards can be seen the heights of Counties Down and Armagh.

Coastal scenery is extremely varied. The sandy flats of Co. Londonderry, overlooked by Benevenagh with its Alpine flora, and the Downhill bluff nearby, lead to the dune areas of Castlerock, Portstewart, and Portrush. East of the last named resort are massive white Cretaceous cliffs, overlain by basalt, with the famous Giant's Causeway only a short distance away. Great cliffs are seen as far as Ballycastle, with sandy bays as relief, the gem being that of Whitepark noted as a Bronze Age settlement. Passing from Ballycastle and on to the 600 feet high geological complex of Fair Head, one sees across the Moyle the island of Rathlin, the nesting haunt of innumerable seafowl and where Robert the Bruce carried on investigations into the habits of spiders !

From Fair Head to Torr Head is an area of rugged splendour, leading to the sands of Cushendun, with its Old Red 'pudding stone' caves, and sweeping inland are the nine lovely Glens of Antrim. From nearby a coast road—*The* Coast Road in fact—built along a 25 feet raised beach, winds its way around precipitous headlands flanking the Antrim Plateau, until Larne is reached, where Mesolithic man had a settlement. The plateau is skirted until Belfast is reached, when Co. Down is entered and a changed scene presents itself, the coastal rocks now being tilted Ordovicians and Silurians ; and so, on to the Mournes, the southern coastal outposts of Northern Ireland. The fens and the bogs make their own appeal.

The whole area is rich geologically, ranging from the pre-Cambrians of the north to Quarternary deposits, the flora and fauna being varied in consequence.

My reason for this brief and very inadequate sketch of the physical and other features of Northern Ireland is to make an appeal to our own local Societies to give more consideration to the importance of preservation by law of several areas, thus backing up the good work being done by the Ulster Society for the Preservation of the Countryside.

In Great Britain much has already been accomplished by the scheduling of suitable areas—here, nothing at all. There is a good deal down on paper it is true, but this is not enough.

In 1946 an Interim Report was presented by a Planning Advisory Board on Amenities in Northern Ireland, which recommended the scheduling of various parts as National Parks in order to safeguard 'scenery of great beauty which is a national asset and not merely of local interest and concern ; to protect the natural flora and fauna ; and to ensure that the public generally—particularly the rapidly increasing numbers of young people who spend their holidays camping, walking and cycling—should have free access to them.'

The suggested area having first claim for inclusion as a National Park—'stretches along the coast from Portrush to Glenarm and inland. . . . The area is high moorland, deep valleys, precipitous headlands and sandy beaches . . . easily reached not only from Belfast and Londonderry, but from the Clyde Valley and Lancashire.'

Next come the Mourne Mountains, 'which rise steeply to the granite crags of their summits more than 2,900 feet above the sea. . . . Their interesting geological formation and the magnificent views they afford over the province and across Carlingford Lough to Eire. . . .'

Then there is the area of Upper and Lower Lough Erne in Co. Fermanagh. 'It is a region of many rare flowers and birds, with great stretches of water dotted with islands, many of which are still covered by dense woodlands, harbouring a native flora and thus giving a picture of the Province before man began to cultivate and build upon it.'

'The Sperrin Highlands with their rounded peat-covered tops, though not so obviously picturesque as the cliffs of Antrim or the lakes of Fermanagh, have those qualities of wild freedom and sweeping breadth of view which are becoming particularly attractive to the city dweller.' While the Slieve Gullion area, including many monuments of

antiquity, ' is of great geological interest and is probably one of the most " storied " districts in the Province.'

So it was in 1946 that the Advisory Board recommended that the Antrim coastal area and the Mourne Mountains area should be defined immediately as National Parks, it being deemed safe to leave the others a little while, but, sad to record, after a lapse of almost six years no move has been made to implement the recommendation.

This is, I consider, an appropriate occasion on which to suggest to members of the many local Societies in Northern Ireland that they should appeal for action to be taken. Concerted effort can do a great deal if persistently carried on, and when the cause is one which means nothing more nor less than the safeguarding of our national—and natural—heritage, no apology is necessary for engaging in such a campaign.

We with leanings to the natural sciences have long been far too retiring ; we have not sufficiently advertised our aims—maybe it is not our way of life—but is it not time we became alive to our responsibility to those who are to follow, and to our indebtedness to those who have passed on ?

I leave this for the Northern Ireland Societies to follow up, for it is constructive work which can be undertaken concurrently with normal activities.

Another task awaiting serious consideration by local Societies—especially in Northern Ireland—is the problem of controlling excessive ivy growth, particularly on trees. Our archaeologists have begun to tackle this matter in so far as ancient buildings are concerned, but go wherever one will in Ulster—where it cannot be said that trees form any main feature of the landscape—ivy will be found both rampant and flourishing.

This is very noticeable on trees growing along roadsides, and it may be argued that the plant lends beauty and character to the scene, largely because its admittedly handsome foliage is of evergreen character—but at what expense ! I know of many once fine trees which now are in the last stages of strangulation, and when these ultimately collapse, as collapse they will, the ivy will fall too, thus the argument put forward as to its aesthetic value is not borne out.

I suggest that local Societies should take up this quite important matter of tree preservation, by calling attention to it in public, by approaching Local and County Councils with a view to official action being taken, and through action by their own members.

It is, of course, possible that a need for similar action arises elsewhere ; if that be so, will delegates other than those who are local please take note.

Having said so much of these particular shortcomings on our own part, perhaps I may now be permitted to switch over and to instance an achievement of our Societies ; one which I venture to say might well be followed up by the far greater number of similar bodies across the Channel.

Until the year 1931, the law relating to the protection of wild birds in Northern Ireland was the same as that for any other part of the United Kingdom. This law, with its many amendments, ranged back to the eighties ; and, in the opinion of us here who considered the protection of wild birds as of paramount importance—scientifically, economically and aesthetically—improvement was obviously overdue.

As no doubt you are well aware the Government of Northern Ireland can exercise its powers for the betterment of its own domestic affairs without reference elsewhere and, in order that advantage might be taken of this in so far as bird preservation was concerned, it was only necessary to create public interest locally.

There was, I am glad to say, no difficulty in doing this, largely through our Scientific Societies, including one which long had been working steadily to achieve a fuller measure of justice for avians—the Ulster Society for the Protection of Birds. It was this body which in 1927 succeeded in convincing the Government of the importance of clarifying existing wild bird legislation, which in turn led to the formation of a Government sponsored Committee, having the duty of making recommendations. These were drafted, duly presented, and in the main adopted. The resulting Bill became law in 1931.

Thus, since that year wild birds in Northern Ireland have enjoyed all the

protection it has been possible to give, regardless of what happens elsewhere. No longer is it possible for a bird and its eggs to be protected in one county but not in those adjacent; county areas have been eliminated in favour of the Six-County unit—that is to say the Northern Ireland area—while it is pleasing to record that shortly after the passing of bird legislation here, the Government of Eire adopted a somewhat similar measure, so that today it can truly be said that Ireland as a whole forms a unit for the better protection of wild birds—with no Border restrictions!

The Northern Ireland Bill was skilfully piloted by the late Senator T. J. Campbell, K.C., who, in his opening remarks before the Senate, said: 'In moving the Bill I do not claim to expert knowledge on the subject. I have no knowledge beyond that of the ordinary lover of birds.'

'T. J.' was an amateur so far as any knowledge of bird life was concerned; he was not even a member of any scientific Society, simply because he had not been led that way; his work lay in the law. The spark of interest for serious consort with nature came to him only when he had reached well past middle-age—then a job of work appeared in the form of the Parliamentary Bill, which was now the concern of any Senator, or Member of the Commons, who cared to become its sponsor. So it happened that a mere lover of birds, from a purely aesthetic and humanitarian standpoint, became their champion. It was mainly through his efforts that the orphan Bill evolved into an Act of Parliament, giving to the birds throughout the Six Counties a status they previously had not enjoyed, and a measure of protection far in advance of that provided in other countries.

No longer could birds be captured by any means, or shot for gain—excepting food species in season. The keeping of wild birds in cages—goldfinches, thrushes, larks, linnets and the like—at the time so prevalent in country districts and even in this city, became a thing of the past, while export or import was prohibited. Nests and eggs were protected too, and penalties for infringement of the Act laid down.

Goldfinches at the time were becoming more and more scarce, because of their export to cross-Channel markets by professional bird-catchers. Today they are not uncommonly met with even within the City of Belfast itself—not in cages, but in the wild state.

An Advisory Committee of ornithologists, together with representatives of many other interests, agricultural, fisheries and sporting, many of whom were connected with the local natural history Societies, was set up to advise the Minister of Home Affairs, who is the responsible Minister, on the general working of the Act.

There are three Categories in the Act, the species contained in each being reviewed from time to time by the Advisory Committee, when adjustments can be made if found necessary, by order of the Minister. The first Category protects *all* birds, with the exception of seventeen species (from time to time it may be more or less) which are black-listed. These at present are—Rook, Jackdaw, Hooded Crow, Starling, Magpie, Irish Jay, House Sparrow, Bullfinch, Wood Pigeon, Sparrow-hawk, Great Black-backed Gull, Lesser Black-backed Gull, Herring Gull, Black-headed Gull, Mute Swan, Cormorant and Shag. None of these species receives any protection.

In Category 2 the names of but three species occur—Blackbird, Chaffinch and Greenfinch—which are protected at all times, except when it is necessary for the owner or occupier of enclosed land to safeguard his crops against their depredations. The nests and eggs of all three birds have absolute protection.

The third Category contains birds especially protected during the close season, from February 1 to August 31, their nests and eggs being safeguarded at all times. Included in the list are the winter Swans, Grey Geese, Ducks, Golden and Grey Plovers, Redshank, Curlew, Whimbrel, Rock Dove, Stock Dove, Coot, Moorhen and Heron. Barnacle and Brent Geese have complete protection for three years from August 1951, while for a like period none of the species contained in this Category may be shot for gain, in order to enable them to establish themselves following indiscriminate and often unlawful destruction during the war period.

It will be noticed that the complications which follow one upon the other in the earlier Acts (actually the present-day law in Great Britain) are swept aside; the whole matter now becomes quite simple and easily understandable, with what is extremely important—a measure of elasticity operating within a definite framework.

Members of the police force, whose duty it is to see that the provisions of the Act are observed, need no longer be ornithological experts, the birds and their eggs which it is essential they should identify being so few in number, comprising only the black-listed species with their eggs and the appearance of those species listed in Categories 2 and 3. Any birds not included can be taken as having complete protection.

The epidemic of Starlings in the vicinity of Trafalgar Square in London not so long ago led to a question being put in the House of Commons. In answer, the responsible Minister regretted that under the Wild Bird Protection Acts in England the Starling is a protected bird and he had no power to reduce its numbers. Under an Act such as that in operation here the Minister could have made an order against the bird, to be in operation until such time as their numbers had been brought within bounds. For example, it was found during the war that our Mute Swan population, at one time of very considerable size, was being systematically depleted because of meat shortage and through consequent activities by commercially-minded gunners. The Minister responsible was, without further legislation, at once able to give the species complete protection for a period of three years. Since then the bird has increased its numbers.

Or conversely, when the Black-headed Gull, then a wholly protected species, was found to be getting somewhat out of hand, the Minister transferred it to Category 1 for an indefinite period.

Members of local Scientific Societies within the Northern Ireland area contributed in no small way to the attainment of this measure of justice for birds, and my purpose in presenting the matter here is to suggest that members of similar Societies in Great Britain, such as are represented in this room today, should make their voices heard in order to secure a similar—or if possible a better—measure for the protection of birds in the sister isle.

Possibly it may be thought I am somewhat presumptuous in putting this matter before you, but, believe me, I am only actuated by a desire to see up-to-date protection of wild birds throughout the United Kingdom. That accomplished may induce changes in Continental countries, which would be extremely welcome. Birds are wanderers, and excessive destruction in any one area—which may, under existing conditions, be quite lawful—is not calculated to benefit other districts.

Piecemeal protection, whilst useful to some extent, is not the full answer to the problem. I should add that in order that bona fide scientific workers may pursue their studies of bird life, there is provision in the Northern Ireland Act for the issuing of licences.

About five years ago I was present by invitation at a largely attended meeting held in the rooms of the Royal Zoological Society, in London, called for the purpose of considering the best method of dealing with bird protection in Great Britain. Representatives were present from England, Ireland, Scotland and Wales, covering all phases of interest. There were official delegates from various Ministries, and from scientific and bird protection societies, whilst others represented sportsmen, wildfowlers, and even hotels and restaurants. All present were concerned with how best to frame a suitable Bird Protection Bill for Great Britain, and following considerable discussion it was finally decided that, with certain adjustments, concerned in the main with the demarcation of geographical areas, the Northern Ireland Act should be accepted as a model.

That was five or more years ago and presumably the birds of Great Britain are in the same position today as they have been for a matter of seventy years, their economic importance and aesthetic value largely ignored and their liberty insecure. I have heard, however, that a Bill for Great Britain is ready, or almost so, though its text has not been published. The call

on Parliamentary time is such as to make the moment of its introduction a matter of speculation which, if unavoidable, is also unfortunate.

We now eradicate insect pests with powders and sprays—useful—yes, for the present. The consideration of such practices as a long term policy does not, however, produce an easy mind. Should we not ask ourselves the reason for needing increased chemical assistance in reducing noxious insects? And further, are we satisfied that our bird population will not in turn suffer from the extended use of insecticides, either by their direct action, or by a reduction of the natural food of many species to a level where it is impossible for them to survive? We heave waste oil into the sea with disastrous results to the seabirds which are the scavengers of our shores. Wildfowl areas are overshot, thus preventing a sufficient return movement of birds to the northern nesting places. We seem to do everything which is or can be detrimental to our bird population; is it not time to stop and think—and *act*?

Nowadays it would appear that new legislation is largely the result of some form of propaganda, scare, or even stunt. I suggest to all delegates assembled here that this is a matter which should concern all Natural History Societies; it is one in which every member can lend assistance. A modern charter for the birds of the British Isles as a whole is long overdue—Northern Ireland has given the lead, while Eire followed; there still is a gap.

In this Address I have attempted to give a brief background to the Ulster Scene, in so far as it concerns the history and activities of our local Societies and have also incorporated remarks on matters considered by me to be of importance to us all—even to those whose thoughts may not run parallel to our own.

To my mind, delegates from Corresponding Societies should be in a position to enter into discussion on such matters at annual gatherings of the British Association. By so doing, I feel sure a measure of wider co-operation among Scientific Societies would arise. I believe I am right in saying this Conference of Delegates came into being many years ago with this very purpose in view, yet even provocative Presidential Addresses seem seldom to have been discussed, while there is no provision for what I might term a parliamentary session, which I consider would be all to the good. It would give added interest and importance to these meetings, and act as a stimulus to local Societies by providing their members with opportunities to make suggestions and voice opinions.

THE SHAPE OF WINGS TO COME[1]

by

D. KEITH-LUCAS

WAR always provides a stimulus to technical advancement but in the United Kingdom the biggest strides in the aerodynamic field have been taken since the war and were the direct consequence of jet propulsion which made it possible to fly at higher speeds and enhanced the importance of being able to do so. Germany had reacted sooner than we to the challenge of jet propulsion and we owe a lot to the lead given to us by the German research work. It is healthy, if a little frightening, to recall that Lippisch in Germany was working on a high-speed Delta design even before the last war.

In this paper I want to review the reasons which have led to the swept-back crescent and Delta wing forms and try to see where these developments are leading us. I shall speak mostly about high-speed aircraft although recent researches have led to at least one rather intriguing shape for low speeds, namely, the Hurel-Dubois light plane which has a very large span and small chord.

Before the war the difference between a high-speed and a low-speed aircraft was mainly one of degree. They were both flying at subsonic speeds and the aerodynamic laws were the same for both. The high-speed aircraft therefore had more power and less drag but was not necessarily very different in outward shape from one designed for low speed. To-day the picture is quite different because by 'high speed' we have come to mean that the aircraft flies at supersonic or, at least, very high subsonic speeds and, by passing through or even approaching the speed of sound, it has entered a new régime of aerodynamics. It is a natural corollary that the aerodynamic shapes have to be different too and as aircraft speeds increase we can expect a continuing divergence between the design of 'low-speed' and 'high-speed' types.

The Purpose of Sweepback.—The outstanding development in high-speed aircraft is the swept wing in its different guises. It is often stated that sweepback enables a wing to 'slide' through the air in rather the same way as a bread-knife or a scythe is drawn across what it is cutting. This, of course, is the principle of the guillotine which always had a swept-back or 'Delta' blade. But we are talking of air which behaves differently from bread, grass or the human neck. Indeed, the analogy is dangerous, if not actually misleading, for, at low speeds, the drag of a swept wing is no less than that of a straight one.

Perhaps the best way to illustrate the purpose of sweepback is to take a rather far-fetched example from a wind tunnel. Let us suppose that we have an untapered wing which spans the tunnel and, if you like, sticks out a bit on each side. The tunnel speed is 400 m.p.h., and the pressure distribution round the wing is, clearly, appropriate to its incidence to the airstream and to the speed. Now let us suppose that the wing is made much longer so that it sticks out a long way from one side of the tunnel and that we proceed to push it through the tunnel at 300 m.p.h. at right angles to the air-flow. Apart from some slight corrections due to skin friction the pressure distribution over the wing is unaltered and is still that appropriate to 400 m.p.h. But if we consider any one point on the wing it is, by simple vectors, in an airstream of 500 m.p.h. to which the wing is swept back at about 37 deg. The flow round the wing is behaving like that round a straight wing at 400 m.p.h., whereas the actual speed is 500 m.p.h. An aircraft

[1] Substance of a paper read before Section G at Belfast on September 8, 1952. For a fuller text, with illustrations, see *Engineering*, September 12, 1952.

with swept wings can therefore fly much faster than a corresponding one with straight wings before meeting the compressibility troubles which, on a straight wing, occur at and around the speed of sound. These troubles include increase of drag, loss of lift, changes of trim, deterioration in stability and control and also the possibility of unpleasant buffeting.

This explanation really amounts to no more than saying that we can resolve the velocity into two components, one at right angles to and the other along the wing and that we can then neglect the flow along the wing. For some strange reason most people find the wind-tunnel analogy easier to visualise. In practice, due to boundary layer and end effects, the advantage which can be realised is only about half of that indicated by this over simple treatment. But, in spite of that, sweepback has two very important contributions to offer. In the first place, it reduces the adverse effects of compressibility and in this respect a swept wing behaves in much the same way as a much thinner straight wing. In the second place, sweepback postpones the compressibility effects to higher speeds and, if the angle of sweep is sufficient, can even postpone them to speeds well above the speed of sound, which is something which thinness by itself cannot do. Both contributions are important but the second one is particularly important if the aircraft is designed for a maximum speed anywhere between, say, 80 per cent. and 150 per cent. of the speed of sound, i.e., for a Mach number between 0·8 and 1·5.

All-Wing Aircraft.—Sweepback was first introduced into aircraft design for quite a different reason. With the development of cantilever monoplanes designers began to think in terms of thicker wings and explored the possibility of using aerofoil sections of up to 25 per cent. thickness : chord ratio. As the size of aircraft increased it became tempting to try to submerge the fuselage by putting it athwartships in the wing, so saving the weight and drag of the fuselage. It also reduced the bending moments at the wing roots, arising from the upward lift forces, by spreading the load more uniformly across the span. The obvious development of this idea was to dispense with the tail because there was no longer anything to support it. The longitudinal stability and control of the aircraft was then restored by sweeping the wings back and, in effect, carrying the tailplane on the wing tips.

One of the objections to using the thick wing sections demanded by this sort of design is that the drag of the wing becomes unduly high. A thick boundary layer of relatively stagnant air builds up round the wing and is shed as a wake from the trailing edge. The drag can be very much reduced if this boundary layer is sucked away near the trailing edge of the wing and it becomes possible to use very thick sections without incurring any penalty in drag over normal thin sections. The engineering difficulties are considerable as the quantity of air which has to be removed is very large but it can be done and it makes the all-wing design both feasible and attractive.

Tailless Aircraft.—We have got so used to the conventional arrangement of aircraft with a straight wing, a long slender fuselage and a tail that we are apt to look on a tailless design as something of an unnatural freak. But if we observe nature carefully we notice that seagulls and ducks and many other birds are, in effect, tailless at least in straight flight, and bats are tailless at all times and are probably the most manœuvrable of all fliers. Gulls use their tails in manœuvring but, as far as one can see, more as air brakes than as elevators and, incidentally, they use their feet in the same way. There is a strong argument for a tailless design on structural grounds. In a pull-out from a dive or in a high-speed turn there is a large upload on the wing and usually, a down-load on the tail. On a conventional tailed aircraft with swept-back wings the moments due to these loads cancel each other out only through the long path up the fuselage and the wing to the centre section. With a tailless design, on the other hand, the down-load of the tail occurs at the wing tips and so we not only avoid the need for a structurally-strong and stiff fuselage but reduce the bending moments in the wings also. There is therefore a potential gain in structure weight as well as in drag, which must be offset against the fact that the tailplane,

if we may call it that, has a shorter moment arm and therefore has to be larger.

Delta or V Wings. — Even without boundary-layer suction there is a good case for the all-wing and tailless aircraft. In America, the controversy between that type of design and the high-aspect ratio wing with a long slender fuselage has been dubbed the ' Big Wing ' against the ' Big Stick,' and long-range bombers have been developed to both formulae. Both types of aircraft were designed for relatively low speeds. As the speeds of military aircraft have increased, the old controversy has died away and a new one has come to take its place. The new argument is between the different shapes of swept wings and the Big Wing and Big Stick appear now as the Delta wing and the swept-back or V wing as used on the Boeing B.47 and B.52 and on the Consolidated B.60. There are all sorts of considerations which lead to one choice or the other. What to do with the engines ; where to put the fuel ; what wing area do we need for landing or for manœuvrability at operating altitudes ; how heavy will the structure be and how is the wing going to distort or deflect at high speed ? This last is one of the big problems of sweepback on high-speed aircraft because of its effects on stability and control.

Aero-Elastic Effects.—We have already seen how sweepback was first introduced as a means of providing longitudinal stability and control on tailless aircraft. The odd part of the story is that nowadays we are concerned by the ill effects of sweepback on stability, both longitudinal and lateral. It seems as if it had turned about and was now ' kicking for the other side ' ; but still, if we keep a careful eye on its behaviour it is very well worth its place in the team for its high-speed qualities. The instability in its character shows itself in various ways, of which the most pernicious are aero-elastic effects, tip stalling and rolling moment due to sideslip. It is the aero-elastic effects, the aerodynamic effects of structural distortion in flight, which often have the biggest influence on the choice of wing-plan form. The fact that sweepback is employed to allow high-speed aircraft to fly at still higher speeds is, in itself, a fair indication that we are likely to meet severe aero-elastic problems because at high speeds even quite small distortions may give rise to large aerodynamic forces.

Aileron Reversal.—An example of the sort of problem which I have in mind is the designer's old bugbear of aileron reversal. Consider, say, the starboard wing of an aeroplane on which the aileron is deflected downwards with the intention of increasing the lift on that side and making the aircraft roll to port. On a perfectly rigid wing the resultant rolling moment would increase as the square of the speed but in practice wings cannot be perfectly rigid and the behaviour is more complicated. The air loads due to the downward aileron produce a twist in the wing, up at the trailing edge and down at the nose, so that the wing loses incidence and loses lift and so produces a rolling moment which is in the opposite direction to that due to the aileron itself. The amount of the twist increases with speed because the air loads become greater in comparison with the elastic restraint of the wing structure. Finally, there comes a speed at which the rolling moment due to the twist equals that due to the aileron and the ailerons become totally ineffective. At still higher speeds the effect of the twist exceeds that due to the ailerons and the aircraft rolls in the opposite direction to that intended by the pilot.

The designer has to see that the ' aileron reversal speed ' falls well outside the operating speed range of the aircraft and to do this he may have to make the wing much stiffer in torsion than would otherwise be necessary. Aileron reversal is a problem which was well known in the days of straight wings but sweepback has made it a more subtle enemy. Not only must we now consider the stiffness of the wing in torsion but also we must see that the bending deflections do not cause a loss of aileron power. It is not immediately obvious why this should be although it is really nothing more than simple geometry.

Washout Due to Flexure.—The loss of tip incidence which results from wing flexure has another very important effect on the handling qualities of swept-wing aircraft. Let us take the case of a pull-out from a high-speed dive. The pilot pulls the stick

back so as to raise the nose of the aircraft and increase the incidence of the wing. He expects that, if he then holds the stick fixed, the aircraft will pull-out at a constant normal acceleration ; that is, in a flight path with a constant radius of curvature. But let us see what happens. After he has pulled the stick back, it takes a moment before the aircraft attitude can change and the lift build up on the wing. When this happens the wings bend slightly upwards and, as we have seen, shed lift at the tips. On a swept-wing aircraft, the tips are well behind the centre of gravity and this loss of lift therefore means a nose-up change of trim tending to make the aircraft tighten in to the manœuvre. In other words, an increase in lift causes a further increase in lift, there is therefore a loss of stability which could have serious consequences on a highly swept wing of high aspect ratio. As we shall have occasion to refer to this effect again, I shall call it ' washout due to flexure,' the term ' washout ' being in common usage to describe a reduction in incidence of the tip of a wing as compared with the root. Some 'washout' is often built into a straight wing to improve the stalling behaviour.

The Aero-Isoclinic Wing.—If we return to the model of the swept-back wing and apply the load farther forward, it is obvious that we shall produce a nose-up twist which will counteract the washout due to flexure and, if we choose precisely the right point at which to apply the load, we can bend the wing with no change of incidence along the span. One way of doing this is to place the torsion box well back in the wing so that the air loads acting at about the quarter-chord line have a considerable moment arm about the torsion box. Even so, the torsional stiffness of the wing may have to be less than usual so as to get the right relationship between twist and flexure. Problems of aileron reversal then have to be faced and it is probably necessary to use either rotating wing-tip controls in place of conventional ailerons or else to use ' spoilers ' of some sort. My preference is for rotating wing-tip controls because, if used as elevators as well as ailerons, they offer a means of overcoming tip-stalling by the simple expedient of increasing the washout as the wing incidence increases. They can also be expected to provide excellent control at high Mach numbers. This solution to the aero-elastic problems has been advocated by G. T. R. Hill, who calls it an ' aero-isoclinic ' wing to indicate that the incidence or inclination to the air-flow remains constant along the span in spite of flexural distortion.

The Crescent Wing.—Another solution to the problem is to crank the wing tips forward from the rest of the wing so that the load on the tips is forward of the axis of the wing. This is the ' crescent wing,' which was pioneered by Arado in Germany and has since been developed by Handley Page in England. It is quite an attractive solution because it also lessens the tendency to tip stalling by reducing the sweepback over the critical tip portion. There is necessarily some weight penalty on the structure due to the crank but it need not be much, particularly as the crank is fairly near the tip. Another slight disadvantage is that the tips have to be very thin in order to make up for the loss of sweep. The aero-isoclinic wing and the crescent wing enable the designer to use higher aspect ratios than would otherwise be possible, and they show to the greatest advantage when the design conditions are such as to demand high aspect ratios.

Forward Sweep.—The tendency to tip stalling of swept-back wings is a problem which the designer of every swept-wing aircraft has to face and do something about. One possible solution is to sweep the wings forward instead of back and so get the stall to start at the wing root. It would then be accompanied by the same unstable nose-up pitching moment which we get with swept-back wings but would be free from the loss of aileron control and sudden wing drop which occurs when the tips stall first. It sounds quite an easy solution and has certain other advantages, including the opportunity for a long tail arm without a long fuselage. The objection is again that of aero-elasticity. Flexure of a swept-forward wing produces an increase in incidence at the tips in exactly the same way as flexure of a swept-back wing causes a decrease in incidence. It is easily visualised by thinking of our model of the swept-back wing and imagining it to be flying in the

opposite direction ; what was a decrease in incidence is now an increase. At first sight it would appear that the increase in incidence forward of the centre of gravity would have the same effect on stability as a decrease in incidence aft. In fact it is much more pernicious because the process tends to be self-energising ; an increase in lift causes an increase in incidence which causes a further increase in lift which causes a further increase in incidence, etc., etc., and at some speed the wing will fail by having its ' neck wrung,' which is the phenomenon known as ' wing divergence.'

Now, on a swept-back wing there is usually no danger of wing divergence because of the washout due to flexure. It is only when we try to correct the washout by using a crescent wing or some other artifice that wing divergence can possibly occur and then only if the correction is overdone—which it obviously must not be. With forward sweep we could also use a crescent wing so as to overcome wash-in due to flexure as well as wing divergence. In this case we must be careful not to under-correct, the penalty for over-correction being only an increase in stability.

It is perhaps surprising that no designer has yet, at least to my knowledge, tried this variant of the crescent wing. Taken a little farther the idea leads to an M wing which has certainly been tried by Nature as in the flight of the gannet. But we must remember that the gannet is not designed for transonic speeds so the reason for the sweep is not the same even though the aero-elastic problems may be similar. The M wing on the gannet may be as much to facilitate wing folding as to overcome aero-elastic effects.

The Delta Wing.—On the evidence of the aircraft which are now flying, designers throughout the world are concentrating on sweepback to the complete exclusion of sweepforward. After our brief excursion we will therefore return to sweepback and to the problem of aileron reversal and washout due to flexure. The simplest solution of any is to make the wing really stiff by keeping the aspect ratio small. The Delta wing exemplified by the Avro 707 is the logical result and it offers very considerable structural advantage over other shapes. There is plenty of room to house a really satisfactory structure and to place the spars just where and how the designer wants them.

Subsidiary advantages are that the small aspect ratio has the property of reducing the effects of compressibility and of making the tendency to tip-stalling less severe ; moreover there is room in the wing to house the engines, fuel and undercarriage. Also the cut-outs, which are necessary to allow the undercarriage to retract, are not nearly so serious as on a narrow wing. On the Boeing B.47, with its very slender wing the undercarriage is housed, tandem fashion, in the fuselage and the engines are slung externally on struts below the wing. How much neater to tuck everything tidily away inside the wing and keep the fuselage as small as possible ! But, in spite of that and for all its virtues the Delta wing is not the answer to all our troubles. Strut-mounted engines may look untidy but they are the favourites of the maintenance engineers. The crews of combat aircraft may also be partial to them on the grounds that the consequences of an engine fire are less serious. Engines buried in a Delta wing may present a beautifully clean installation but the jet pipes and/or the intake ducts are undesirably long especially when the aircraft is large and there must be some weight penalty and loss of efficiency as a result.

What is more important, however, is that when altitude requirements demand a wide span, the wing area of a Delta becomes unnecessarily large and it has to be paid for in the most precious of aeronautical currency, namely drag and weight. The weight saving on the basic structure can easily be nullified by the weight of the skin sheeting to cover so large an area plus the weight of the large chordwise ribs and, most serious of all, the weight of fuel burnt in overcoming the skin-friction drag of the additional wing area. The conclusion which can be drawn is that there is a strong case for the Delta wing in the smaller sizes and especially when the sweepback is 60 deg. or more. On very large aircraft of, say, 200,000 lb. and upwards, the Delta becomes uneconomical and a V wing,

probably with strut-mounted engines, is then the obvious choice. At intermediate sizes around 100,000 lb. the choice is not so simple and the best solution may be a V wing with engines buried in the wing roots, which can be enlarged if necessary, as on the Valiant.

Supersonic Shapes.—The drag coefficient of an aircraft wing is almost constant at subsonic speeds but peaks up to a very much higher value at transonic speeds and then settles down again to an intermediate value at supersonic speeds. The precise values are not easily obtained because the ordinary wind-tunnel techniques break down at transonic speeds. The effect of sweepback, as we have already seen, is both to reduce the drag rise and to delay it to higher speeds.

For very high speeds where the degree of sweep required would be impracticable, it may therefore be better to have no sweep at all. Put another way we must either have enough sweep to delay the compressibility troubles to speeds beyond the range in which we are operating or else we can hurry on the troubles by using no sweep at all so that all is well again at the operating speeds. What we must not do is to fly in the troubled region of mixed subsonic and supersonic flow. If we favour the straight wing we must make it very thin because the wing will then be working in pure supersonic flow where the drag penalty for thickness is great. It seems that before long we shall be forced to use thickness : chord ratios as low as 3 per cent. or 4 per cent., and the wing will therefore have to be of small aspect ratio in order to be sufficiently stiff and strong. I imagine that it will be worth while to provide just sufficient sweepback to overcome any tendency to wing divergence. There is always the possibility of wanting to fly at lower speeds when climbing, manœuvring or if damaged in combat, and it is well not to have to worry about forbidden speeds at which the drag is high and there are uncomfortable trim changes.

The Landing Problem.—One of the big problems will be to get such highly swept wings to give adequate lift at low speeds. There are also likely to be some difficulties with longitudinal and lateral stability. It has been said that the hardest part of designing a supersonic aircraft will be to make it fly slowly, and it is probably true if the designer allows very little compromise with high-speed performance. Take-off may present a problem but the thrust necessary to fly at very high speeds is likely to be adequate for unassisted take-off unless the wing lift is very poor or the wing loading is very high. If it is not good enough, the take-off can always be assisted by catapulting or by quick-burning rockets. If even these are not sufficient we can return to the principle of air-launching from a parent aircraft in the manner that was pioneered by Short Brothers at Rochester and has subsequently been used for supersonic research aircraft in America. The real problem is likely to be in landing where these aids cannot so readily be used.

Here then is a challenge—all sorts of mad ideas come to mind. Should we ' unsweep ' the wings for landing as on the experimental Bell X-5, in which the wings are pivoted about a vertical hinge at the root so that the angle of sweep can be varied in flight ? It may be the answer although it is bound to introduce a penalty in weight and possibly in drag too, but it can be done as proved by the Bell X-5 and by the Westland-Hill Pterodactyl Mark IV, which flew as long ago as 1931. Birds often use this technique but nature can make moving joints with much less weight penalty than we can and without having to consider the maintenance aspect in quite the same way. The engine thrust to achieve the supersonic speeds must be at least comparable with the weight of the aircraft so we might possibly swivel the engines round to give lift instead of propulsive thrust. It sounds a bit complicated and the control problems are sure to be very involved.

Perhaps the best way out of this difficulty is to avoid it altogether which we could do if we arranged for the high-speed aircraft to link up with a parent aircraft in flight, using a technique similar to flight refuelling. This is not a very happy idea as we must be absolutely sure that the parent never goes unserviceable while its chicks are on a mission and, moreover, that it never falls a victim to enemy attack. We might even consider stopping the aircraft in flight by air brakes and

forward-firing rockets and then letting it down on parachutes or by a retractable rotor as a helicopter. It is obviously impossible to do the helicopter scheme without fantastic complication and the parachute would be much too bulky to stow without severe drag penalty. We may then be forced to put up with the high landing speeds by using arrester gear. This at least is a practical suggestion but it would involve great cost in runways and arrester gear.

Alternatively, we might put up with the high landing speeds if we make the aircraft into a flying boat and alight on water. But, in spite of my faith in the future of water-based aircraft, I believe that there will always be a need for landplanes and an alternative solution applicable to landplanes will have to be found.

Atomic Power.—Our discussion so far has been about the foreseeable developments of fixed-wing aircraft using the types of propulsion which are already familiar to us. We have not even considered helicopters or guided missiles. Just round the corner are much more exciting things like space ships, artificial satellites and atomic-powered air liners. It is very tempting to plunge into speculation as to the shape of these future craft, but it is doubtful whether there is any value in doing so until our knowledge is on firm enough foundations to support the structure of a logical argument.

The atomic-powered air liner might be a possibility to-day but it would have to be extremely large and would probably be uneconomical on account of the enormous weight of the screening necessary round the reactor unit. We could argue from that single premise that the aircraft ought to be a flying boat because of the high landing weight which, on a landplane, would mean a heavy undercarriage and the need for airfields with exceptionally long runways capable of taking very heavy loads. All of this is an expense which the taxpayer would be glad to dodge. The reactor unit and engine would be in the hull of the boat and the passengers would have to be housed in the wing or in the wing-tip floats.

We could now prepare a sketch of the atomic-powered flying boat but it would not be altogether convincing because it would strike us as old fashioned. We have indeed been applying the old arts of aircraft design to a new form of propulsion, whereas a much more radical approach is needed. The jet fighters of to-day are not the Spitfires or Hurricanes of yesterday with new engines in them but are of new shapes to suit the new conditions. What shape the atomic-powered aircraft will be is a subject deserving much thought when we know enough about the characteristics of the engine. Will the engine really weigh so much or shall we again find that what we thought was fundamental is no more than a passing phase? Somehow it seems unlikely that the atomic-powered aircraft will look old fashioned. It will come as a challenge and a stimulus to new research in structures and aerodynamics but this time Britain must lead and not wait to pick up the threads from a narrowly-defeated enemy. There must therefore be a close understanding between the atomic research establishments and the aircraft industry. Unnecessary secrecy will deprive the country of the chance to lead in the atomic age.

In conclusion, I wish to thank the Directors of Short Brothers and Harland, Limited, for permission to publish this paper.

SEISMOLOGICAL INVESTIGATIONS

FIFTY-SEVENTH REPORT of COMMITTEE on Seismological Investigations. (Dr. R. STONELEY, F.R.S., *Chairman*; Lt.-Col. E. TILLOTSON, *Secretary*; Mr. E. F. BAXTER, Miss E. F. BELLAMY, Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Mr. B. C. BROWNE, Dr. E. C. BULLARD, F.R.S., Dr. K. F. CHACKETT, Dr. G. E. R. DEACON, F.R.S., Dr. A. T. J. DOLLAR, Rev. H. NORMAN EDGE, Dr. A. E. M. GEDDES, O.B.E., Prof. G. R. GOLDSBROUGH, C.B.E., F.R.S., Dr. M. N. HILL, Dr. O. J. R. HOWARTH, O.B.E., Mr. J. S. HUGHES, Prof. H. JEFFREYS, F.R.S., Mr. E. N. LAWRENCE, Dr. A. W. Lee, Dr. A. O. RANKINE, O.B.E., F.R.S., Rev. C. REY, S.J., Dr. G. D. ROBINSON, Mr. H. V. SHAW, Sir FRANK SMITH, G.C.B., G.B.E., F.R.S., and Dr. P. L. WILLMORE.)

PERSONAL

The committee offers its congratulations to Dr. P. L. Willmore on his appointment at the Dominion Observatory, Ottawa. He expects, in addition, to spend some months assisting in setting up the network of seismic stations that the Colonial Office has established for the study of vulcanological activity in the West Indies.

THE GRAY-MILNE FUND

During the year ended June 30, 1952, no actual disbursements have been made from this fund, although a small sum in respect of secretarial expenses is owing. The sum of £400 is still invested in Defence Bonds; the receipt from the trustees of the late Dr. J. E. Crombie of a cheque for £1,000 recalls the many benefactions of Dr. Crombie to British Seismology. By his will he provided that on the death of his wife his trustees should allocate this sum to the B.A. Seismological Committee 'to be applied towards assisting in the investigation of seismological research' (B.A. Report, 1933). Mrs. Crombie died on August 24, 1951; for the time being the bequest is held by the Treasurer of the British Association.

GRAY-MILNE FUND

Receipts	£	s.	d.
Balance at Bank, July 1, 1951	279	13	4
Trust Income . . .	80	14	10
Interest on Defence Bonds .	10	0	0
	370	8	2
Balance at Bank, June 30, 1952	370	8	2

INSTRUMENTS

The instruments belonging to the Committee are located as follows:—

Milne-Shaw Seismographs,	
No. 1 . . .	Science Museum, South Kensington.
„ 3 . . .	Edinburgh.
„ 4 . . .	Downe, Kent.
„ 6 . . .	Hermanus, South Africa.
„ 27 . . .	Perth, Western Australia.
„ 63 . . .	Suva, Fiji.
Seconds Regulator Clock . . .	Suva, Fiji.
Jaggar Shock Recorder	Fort Augustus.

The Seismograph at Down House, Downe, Kent, remains in storage.

A globe and protractor has been transferred from Down House to the Homestead, Menston-in-Wharfedale, Yorkshire, and is being used by the Secretary.

The Milne Library has been transferred from Down House to the Science Museum, South Kensington.

THE INTERNATIONAL SEISMOLOGICAL SUMMARY

By J. S. Hughes

During the period since the last report two new workers have been engaged on the staff. Mr. B. Elliott came to us in August 1951, and Miss G. Turner a month later to work on the clerical side assisting Mrs. Sanders. Mrs. Sykes, who has been with us since the move to Kew in 1947, has left and will be replaced in September by Miss Howe, Miss Marlow at the same time replacing Miss Turner. Mr. Elliott will be due for National Service at the end of the year, a very regrettable but inevitable loss.

As a result of increased staff the whole of the MSS. for the I.S.S. 1941 volume are in the hands of the printer. Part III may be out any time. Further, 1942 has been prepared to the middle of August. It is hoped that the temporary slowing up due

to change of staff will soon be made good when we are up to strength again.

The earlier part of 1942 was very thin in seismological observations. Later these tended to become more normal. The fact that no further data came in after we began work on the year shows this to be a natural phenomenon and not due to the effect of war on observing stations.

A circular has been sent out to request observers to send in data for 1943 and subsequent years. Work on these will soon be started and it is to be hoped that the extra trouble of interpolating delayed records can be avoided.

DEPARTMENT OF GEODESY AND GEOPHYSICS, CAMBRIDGE

EXPERIMENTAL.—(*a*) During June and July, 1951, an investigation was carried out by Dr. Hill and Mr. MacFarlane in the estuary of the River Erme in S. Devon, when the buried channel was explored by the refraction method in the region between High and Low Water Marks.

Since all the equipment was transported by hand-trolley, and because of the restricted period during which experiments could be made, the ' fixed spread ' method was used throughout the survey. A complete profile of the valley floor was obtained, the rock bed being at—90 ft. O.D. at L.W.M.O.T.

In March, 1952, a similar survey was carried out in the estuaries of the rivers Taw and Torridge in N. Devon. In these experiments motor and amphibious transport was available and the more satisfactory ' moving spread ' refraction method could be employed. The buried channel was located at —100 ft. at the mouth of the rivers, at —65 ft., 5 miles from the mouth in the Taw, and at —70 ft., 2 miles from the mouth in the Torridge.

(*b*) In the neighbourhood of Pendulum House, Cambridge, some exploratory seismic shooting has been carried out.

(*c*) At the time of writing, Mr. B. C. Browne and Dr. M. N. Hill are about to begin an investigation of the layering of the North Atlantic Ocean by exploding depth charges. Two ships, H.M.S. *Scott* and R.R.S. *Discovery II*, are being used.

THEORETICAL.—The problem of Rayleigh Waves in a double surface-layer, though involving heavy algebra and lengthy subsequent computation, is important if use is to be made of Rayleigh Wave data to check the evidence of layering of continents afforded by the observed dispersion of Love Waves. To obtain a rough approximation to the wave velocity and group velocity of Rayleigh Waves, Dr. Stoneley has followed Prof. Jeffreys's use of the Rayleigh approximation, and has shown that Rohrbach's observations on Rayleigh waves give results consistent with those from Rohrbach's data on Love Waves.

The method, however, overestimates the wave velocity by ten per cent. or more ; accordingly Dr. Stoneley has worked out the exact equation giving the velocity of Rayleigh Waves in a double surface layer. This equation, in which a 10-row determinant is equated to zero, is being solved numerically by the Mathematical Laboratory at Cambridge. Dr. Stoneley has made some progress with the problem of the propagation of surface waves of Rayleigh type in a medium with cubic symmetry. His Presidential Address to the International Association of Seismology on ' The International Seismological Summary—an Example of International Co-operation in Science ' has been printed with the aid of a grant from U.N.E.S.C.O. and circulated with the I.S.S.

UNIVERSITY OF DURHAM—SEISMOLOGICAL OBSERVATORY

By E. F. Baxter

1. The Irish Sea earthquake of January 11.01 hrs. has been detected on the Milne-Shaw seismograms at Bidston and Durham and on the S.P.V. seismogram at Kew. These readings confirm the epicentral determination of Father R. E. Ingram of Rathfarnham as 52° 50′ N., 05° 30′ W. with time of origin 01.50.33 G.M.T.

2. The Winster (Derbyshire) earthquake of February, 1952, 22.09 hrs. has been detected on the Milne-Shaw seismograms at Durham at 09.20.04 G.M.T.

3. The hourly readings of microseisms for the period March 16 to April 5, 1952, requested by the Director of the Bureau Central International de Séismologie of the U.G.G.I., have been made from the Durham seismograms and sent to Strasbourg.

THE EARTH TREMORS AT WINSTER (NEAR MATLOCK, DERBYSHIRE)

Extracts from a report by Mr. Sydney G. Clift

Earth tremors occurred at Winster in 1952 :

Feb.	22	09.20 hrs.	M.M. Intensity. VI at Winster
„	24	00.30 „	
Mar.	17	20.40 „	
April	15	04.00 „	
„	15	19.35 „	M.M. Intensity IV at Winster

From time to time the area has been the site of earth tremors, a well authenticated example occurring in 1775 and the most recent before the present group in 1903 and 1904.

On February 22 this year at about 9.20 a.m. without any preliminary warning a relatively severe twin tremor with accompanying noise effects occurred, the main damage being concentrated in Main Street, Winster, where several houses lost their stone chimney stacks and the church a stone cross. Lesser damage was sustained in the upper part of the village and in farms on Bonsall Moor to the south-east, though there the tremor and sound appeared equally disturbing to stock and people alike.

The field investigation occupied four days from April 22 to 25, following a preliminary visit on April 17. Some 36 square miles were surveyed and the effects plotted show that the two tremors (February 22 and April 15) were felt over areas of approximately 16 and 14 square miles respectively though the sound effect had a somewhat lesser extension than the tremor in each case.

Conclusions :—The earth tremors were minor earthquakes due to slight adjustments taking place along a fault line at considerable depth in the crust. In effect the movement occurred along a very deep extension of one of the many mineralised faults which intersect the limestone in the Winster area. This system of branch faults is a continuation of the well-known Crich-Cromford-Bonsall fault belt which exhibits a north-west-south-east or Charnian trend, a feature of some significance and reflected in the shape of the epicentral area of the February tremor.

THE 'EARTHQUAKE HOUSE' AT DRUMEARN, COMRIE, PERTHSHIRE

By Dr. A. T. J. Dollar

This small stone building, now needing repair, is of considerable interest and importance in the historical development of seismology.[1] Particularly, it commemorates the pioneer work of the British Association in this connection, through the vigorous endeavours of D. Milne-Holme, Sir W. Thomson, G. Forbes, J. Bryce, J. Brough, and the Comrie investigators P. Drummond, J. Drummond and P. MacFarlane, all but the last two of whom served on the first two Committees appointed by the Association 'to register the shocks of earthquakes in Scotland and Ireland'—the pair of bodies from which the present Committee for Seismological Investigations is directly descended.

The House stands among conifers on a bluff of solid rock in the grounds of 'Drumearn,' about half a mile west of St. Kessog's Church, Comrie. Externally it is 10 ft. × 10 ft. by 14 ft. in height, with mortared walls of local metamorphic rocks some 18 ins. in thickness, and a paved stone floor above which is a pyramidal slate roof. Its solitary window is boarded up.

In it was placed one of the last, if not the last, of a series of eleven (or possibly thirteen) seismometers (mainly inverted pendulums) erected by these two early Committees in different parts of Perthshire and Argyll. This particular one was installed in 1874, and maintained thenceforth, by Peter Drummond, the then owner of Drumearn, at the instigation of the second Committee, after what proved to be a temporary resumption of seismic activity had occurred at Comrie in 1867, as a sequel to nearly twenty years of relative quiescence.

Made according to a design of Robert Mallet, the instrument consisted of two smooth narrow wooden planks, set N.-S. and E.-W. respectively, in a horizontal plane, each plank bearing six carefully turned boxwood cylinders, of equal height (i.e. about 12 ins.) but of different diameters (up to about 2 ins.), which stood on end, and were so separated that no one of them would strike a neighbour, on

[1] It was visited in 1925 by Prof. H. H. Turner (see B.A. Report, 1926).

being thrown down. In the quadrants between the planks was fine dry sand, levelled to the top surfaces of the planks, for the purpose of recording, in terms of a 'dent,' the direction in which any of the cylinders might be overthrown.

The intention was that this equipment should (i) give some indication of the maximum intensities and 'horizontal directions' of local tremors, and in so doing, (ii) afford a check on corresponding records provided by the seismometer then set up in the tower of St. Kessog's Church.

However, the recrudescence of seismic activity which began about 1867 was so mild and short-lived that the capabilities of the instrument do not seem to have been put to any rigorous test at that time. Later, it is recorded that, as the slight tremors of January 14 and 16, 1878, at Comrie did not overthrow any of the cylinders, a pair of 'increased delicacy' (? especially small diameter) was added to each of the two sets of six, but whether this change led to records of subsequent tremors is not mentioned in available literature. Certainly Mr. John Gilbert, who continues to live in Comrie to-day, remembers seeing the cylinders standing, as described, in 1889, when he was a boy of about twelve years, which may indicate that the instrument was still being maintained in or about that year.

Since then the planks and cylinders have disappeared, and the stone floor is now bare of even the small traces of white sand which were still visible in 1911, but the building remains, and it would seem not inappropriate that this should be suitably repaired, through the agency of the British Association, if the present owner is agreeable, and some permanent indication of the part which both this building and Comrie earth tremors have played in the development of seismology should be attached to one of the walls in the form of a small engraved plate.

INTERNATIONAL CO-OPERATION IN SEISMOLOGY

A number of British geophysicists attended the Ninth General Assembly of the International Geodetic and Geophysical Union at Brussels in 1951. The Assembly was preceded by a meeting of the Committee on the Physics of the Earth's Interior (COPEI), which in effect became a joint meeting of several of the International Associations. The success of this meeting, which included symposia on Thermal Problems, the Constitution of the Continents and Oceanic Deeps, the Core of the Earth, and (during the Assembly) Movements of the Earth's Crust, emphasised the need for co-operation among the Associations and for the revision of the status of COPEI, either by including the COPEI topics under the aegis of one of the existing Associations or by developing COPEI into a new Association. Eventually it was agreed by the Assembly that the Association of Seismology should be enlarged and renamed 'The International Association of Seismology and the Physics of the Earth's Interior.'

The meetings of the Association of Seismology were very successful, and included joint meetings with other associations on Microseisms and on Exploring the Ocean Floor. The experiment of grouping the scientific communications under certain broad divisions, each having its own rapporteur who presided at his particular session, proved very advantageous, and has led to the appointment of rapporteurs for the various sub-divisions of the enlarged Association. An important step was taken in setting up a Commission of the Association to study European Seismological Problems, which will provide for the interchange of ideas among European seismologists between General Assemblies. This Commission will hold a meeting at Stuttgart in September, 1952.

The Officers for the present triennium are :

President :	Prof. B. Gutenberg
Vice-Presidents :	Prof. H. Jeffreys
	Prof. P. Caloi
General Secretary :	Prof. J. P. Rothé

Miscellaneous

1. The Secretary has continued to read the Edinburgh seismograms, and those completed have been distributed.

2. Mrs. Kingdon-Ward, who was camping with her husband near the epicentre of the Great Sikang-Assam Earthquake of August 15, 1950, has recently published a book about the district and the earthquake effects (*My Hill So Strong*. Jean Kingdon-Ward. Jonathan Cape. 1952).

BELFAST MEETING

SECTIONAL TRANSACTIONS

Any references to publication supplied by authors will be found on page 332.

SECTION A

MATHEMATICS AND PHYSICS

September 4

Contributions to experimental physics from Britain, Presidential Address by Prof. A. M. Tyndall, C.B.E., F.R.S.

Mr. P. H. Fowler.—(a) *Balloons for cosmic ray studies at high altitudes.* (b) *The nature of the primary cosmic radiation.*

Dr. H. D. Keith.—*The surface reduction of silver halide crystals.*

September 5

Physics of the high atmosphere:

Dr. S. F. Singer.—*High altitude research with rockets.*

Dr. F. E. Roach.—*Upper atmosphere radiations: geographical studies.*

Prof. D. R. Bates.—*Theoretical work on upper atmospheric physics.*

Mr. W. R. Piggott.—*The morphology of the ionised layers.*

September 8

Electrical discharges in gases:

Prof. F. Llewellyn Jones.—*The electrical breakdown of gases.*

Dr. C. Grey Morgan.—*Cold electron emission and its role in gaseous discharges.*

Dr. R. L. F. Boyd.—*Ionic constituents in gaseous discharges.*

Prof. K. G. Emeleus.—*Ionic oscillations.*

Dr. A. von Engel.—*High frequency discharges in gases.*

Mr. C. E. R. Bruce.—*The leader strokes of lightning and spark discharges.*

September 9

Moisture relations and fibre processing:

Mr. J. A. Matthew.—*Moisture absorption by fibres and its effect on fibre properties.*

Dr. A. B. D. Cassie.—*Moisture relations and clothing comfort.*

Dr. M. N. Hill.—*Seismic prospecting in the deep sea.*

SUB-SECTION A*

MATHEMATICS

September 5

Dr. J. Bronowski.—*The logic of experiment.*

Prof. J. L. Synge, F.R.S.—*Space-time pictures and de Broglie waves.*

September 8

Mr. J. W. Herivel.—*Entropy.*

September 9

Dr. E. F. Collingwood.—*On some classical notions of the theory of functions.*

Prof. E. H. Neville.—*A code for tree structure.*

SECTION B

CHEMISTRY

September 4

The advancing front of chemistry, Presidential Address by Prof. W. Wardlaw, C.B.E.

Dr. D. H. R. Barton.—*Progress in organic chemistry.*

Prof. A. R. Ubbelohde, F.R.S.—*Advances in inorganic and physical chemistry* (read by Dr. R. C. Pink).

September 5

Fibres, old and new:

Dr. D. W. Hill.—*Introduction.*

Dr. A. J. Turner, C.B.E.—*Naturally-occurring fibres.*

Dr. A. R. Urquhart.—*Natural-polymer fibres.*

Dr. Rowland Hill.—*Synthetic-polymer fibres.*

September 8

Food processing:

Prof. H. D. Kay, C.B.E., F.R.S.—*Introduction.*

Dr. A. J. Amos.—*The chemistry of breadmaking.*

Dr. J. A. Lovern.—*Chemistry and advances in fish processing.*

Mr. P. N. Williams.—*Processing of fats.*

September 9

Biologically significant macro-molecules:

Prof. M. Stacey, F.R.S.—*Polysaccharides of medical importance.*

Dr. B. E. Conway.—*Physical chemistry of deoxyribonucleic acid.*
Dr. G. A. Gilbert.—*Enzymes for building natural and synthetic starch.*

SECTION C

Geology

September 4

Prof. J. Kaye Charlesworth.—*The geology of the Belfast district.*
Mr. A. Fowler.—*Stratigraphy and structure of the Lough Neagh Basin.*
Mr. A. Fowler.—*The Permian of Grange, Co. Tyrone.*

September 5

The Carboniferous succession in Northern Ireland:
Prof. T. N. George.—*Introduction.*
Dr. I. M. Simpson.
Mr. D. H. Oswald.
Mr. A. Fowler.

September 8

Some aspects of geological research and their practical application, Presidential Address by Dr. J. E. Richey, F.R.S.
Mr. V. A. Eyles.—*The interbasaltic laterites and associated beds in Co. Antrim.*
Dr. W. Campbell Smith, C.B.E., M.C.—*A new discovery of silica-glass near a crater in western Sahara: evidence in support of a meteoritic origin for tektites.*

September 9

Irish fauna and flora. Joint Session. See entry under Section D.

Session A

Dr. S. I. Tomkeieff.—*A new approach to the Periodic System.*
Dr. J. C. Harper.—*The Ordovician succession west of Drogheda.*
Mr. G. J. Murphy.—*The Ordovician rocks near Tramore, Co. Waterford.*
Mr. R. N. Cope.—*The Silurian rocks of the Devil's Bit Mountain, Co. Tipperary.*
Mr. W. S. McKerrow.—*The lower Palaeozoic rocks of Killany Harbour.*

Session B

Dr. E. D. Lacy.—*Volcanic glasses.*
Dr. A. T. J. Dollar.—*An arctic study of explosive fissure eruption.*
Mr. E. M. Patterson.—*Basalt lavas and vent agglomerates in the northern part of the Antrim plateau.*
Dr. S. I. Tomkeieff.—*The Tertiary basalt lavas of Antrim.*
Mr. J. A. Robbie.—*A tunnel in the Mourne Mountains.*

September 10

Mr. T. D. Ford.—*An intra-formational unconformity in the Ingleton coalfield.*
Dr. W. D. Gill.—*Tables for use in geometrical projection of geological structures.*
Mr. K. A. Joysey.—*Evolution and relative growth in Echinoderm populations.*
Mr. B. E. Manistre.—*Metamorphic rocks of the Ox Mountains.*
Mr. J. E. Gillott.—*Preliminary report on the Manx slates.*
Dr. A. Lamont.—*Ecology and classification of Trilobites.*

SECTION D

Zoology

September 4

Some problems of parthenogenesis, Presidential Address by Prof. A. D. Peacock.
History and work of the Belfast Naturalists' Field Club. Jointly with Sections C, E, H, K.
Mr. G. B. Adams.—*A brief history of the Field Club.*
Mr. J. J. Brown and Mr. W. J. Weatherup.—*Recent work of the Field Club.*
Recent advances in cytology :
Mr. I. C. Smith.—*The cytology of Pharaoh's Ant :* Monomorium pharaonis (*L*).
Dr. R. J. Goldacre.—*The tail of Amoeba in locomotion and division.*
Prof. H. G. Callan.—*Amphibian Oocyte nuclei.*
Dr. W. S. Bullough.—*Hormones and the replacement of the skin.*

September 5

The comparative physiology of muscle. Jointly with Section I.
The behaviour of social insects. Part 1 : Ants.
Dr. J. H. Sudd.—*Colony formation in Pharaoh's Ant.*
Dr. D. M. Vowles.—*Individual behaviour patterns in ants.*
Mr. S. J. Holt.—*The foraging activity of Wood Ants.*
Prof. J. E. Webb.—*The swarming behaviour of Termites.*
The behaviour of social insects. Part 2 : Bees.
Mr. C. R. Ribbands.—*New evidence concerning the language of honey-bees.*
Dr. C. G. Butler.—*The behaviour of worker honey-bees at the hive entrance.*
Mr. G. D. Glynne Jones.—*Chemoreception in the honey-bee.*

September 8

The biology of confined sea waters. Jointly with Section K (Botany).
Prof. L. P. W. Renouf.—*Some notes on Lough Ine, Co. Cork.*
Mr. J. F. Sloane.—*Lough Ine and the Rapids ; Hydrography.*

Dr. F. J. Ebling.—*Lough Ine and the Rapids; Fauna.*

Dr. Helen Blackler and Mrs. N. MacMillan.—*The biology of Lough Foyle, Co. Donegal.*

Mr. J. Drinkwater and Miss D. Ballantine.—*The biology of the Loch of Reiff, Wester Ross.*

Mr. J. E. Morton.—*Digestive mechanisms in ciliary feeders.*

Dr. A. E. Oxford and Dr. Brenda Sugden.—*A reconsideration of the role of ciliate Protozoa in ruminant digestion.*

Mr. R. V. Gotto.—*Observations on ascidicolous Copepods.*

Dr. J. D. Smyth.—*Egg-shell formation in Trematodes and Cestodes as demonstrated by selective staining.*

September 9

The Irish fauna and flora. Jointly with Sections C and K.

Prof. J. Kaye Charlesworth.—*The physical conditions of the British Pleistocene.*

Dr. A. Farrington.—*Glacial refuges in Southern and Western Ireland.*

Mr. G. F. Mitchell.—*The immigration of fauna and flora into Ireland in late glacial and early post-glacial times.*

Dr. J. Heslop-Harrison.—*Modern distribution of Irish plants and historical problems.*

Col. Niall MacNeill.—*Irish dragonflies.*

Mr. C. D. Deane.—*The vertebrate fauna of Ulster woodlands.*

Human biochemical genetics. Jointly with Sections I, and J.

Prof. L. P. W. Renouf.—*Ecological and other observations on sponges.*

Dr. D. J. Crisp and Dr. P. N. J. Chipperfield.—*The seasonal settlement of barnacles in British waters.*

Mr. G. Williams.—*The biology and early development of* Leptasterias islandica.

Mr. C. Edwards.—*The ecology of species of* Marinogammarus.

Miss A. Duncan.—*The breeding of* Arenicola marina *L. in the British Isles.*

SECTION E

Geography

September 4

Prof. E. Estyn Evans.—*Belfast and its region.*

Mr. D. A. Hill.—*Land use in E. Ulster.*

Dr. Emrys Jones.—*The social geography of Belfast.*

September 5

Mr. V. B. Proudfoot.—*Erosion surfaces in the Mourne Mountains.*

Mrs. J. M. Graham.—*Transhumance in Ireland.*

Dr. H. C. Brookfield (read by Dr. G. H. Dury).—*An aspect of Cork City in the nineteenth century.*

Mr. A. E. Smailes.—*Town and region in Ulster: a study of urban fields with special reference to Ballymena.*

Dr. G. J. Butland.—*Settlement and population changes in the S. Chilean provinces of Magallanes and Aysen.*

Dr. A. Geddes and Mr. A. T. A. Learmonth.—*Variability of population change in India and regional variations therein.*

Mr. E. V. Lane.—*Some aspects of the early development of the British rubber industry.*

September 8

Aspects of settlement in the overseas Dominions, Presidential Address by Prof. R. O. Buchanan.

Mr. R. Lawton.—*An early nineteenth century muster list of Craven, Yorkshire.*

Mr. D. J. Sinclair.—*The geographical distribution of productivity in the Scottish coalfields.*

Location of industry in Northern Ireland. Jointly with Section F.

Prof. Wilfred Smith.—*The principles of the location of industry and their application to Northern Ireland.*

Mr. N. Cuthbert.—*Industrial location in Northern Ireland* vis-à-vis *the rest of the United Kingdom.*

Mr. B. J. Ahern.—*Industrial problems facing the Government of Northern Ireland.*

September 9

Mr. J. D. Birch.—*Certain aspects of the Manx agricultural landscape.*

Mr. A. H. Shorter.—*Field patterns in Devon.*

Mr. H. Bowen-Jones.—*Land reform in Calabria and some notes on agricultural planning.*

September 10

Dr. G. H. Dury.—*A new approach to the problem of underfit rivers.*

Mr. H. Carter.—*The growth and grading of towns in south-west Wales.*

Mr. F. H. W. Green.—*Local transport and rural-urban relationships in Western Europe.*

SECTION F

Economics

September 4

Dr. C. R. Fay.—*Tenant right in Ulster—an historical view.*

Mr. J. Clews.—*The Irish worker and English industry.*

Prof. H. O. Meredith.—*Fifty years of economics.*

September 5

Full employment in retrospect, Presidential Address by Prof. D. T. Jack, C.B.E.

September 8

Mr. J. Lanner.—*The rediscovery of bank rate and the London money market.*
Prof. G. A. Duncan.—*The Irish Republic's balance of payments.*
Location of industry in Northern Ireland. Jointly with Section E.

September 9

Mr. H. C. Hillmann.—*German economic policy since* 1948.
Prof. G. L. S. Shackle.—*Economics and sincerity.*
Prof. C. F. Carter.—*The troubles of transport.*

SECTION G

Engineering

September 4

Session A

Biology of flying. Joint Session with Section I.

Session B

Mr. D. A. Stewart.—*Vibrated concrete.*
Prof. R. O. Kapp.—*Calculation of transmission line constants.*

September 5

Progress in aeronautical science and engineering, Presidential Address by Sir Ben Lockspeiser, K.C.B., F.R.S.
Dr. Denis Rebbeck, C.B.E.—*Ships and ship-building in Belfast.*

September 8

Session A

Mr. D. Keith-Lucas.—*The shape of wings to come.*
Mr. H. Knowler.—*Future development of the flying boat airliner.*

Session B

Chemical engineering in industry :
Prof. D. M. Newitt, M.C., F.R.S.—*The training of chemical engineers.*
Dr. E. H. T. Hoblyn.—*The chemical engineer in industry.*

September 9

Session A

Mr. F. W. Meredith.—*Servo mechanisms in aircraft.*
Lt.-Comm. J. R. D. Walker.—*Ships and servo mechanisms.*

Session B

Papers by young engineers :
Mr. T. M. Charlton.—*The analysis of statically indeterminate structures by the complementary energy method.*
Mr. A. G. H. Coombs.—*The effect of shot peening on the fatigue life of steel.*
Mr. A. V. Pringle.—*Textile engineering.*
Mr. J. B. Caldwell.—*The bending strength of corrugated plate.*

SECTION H

Anthropology and Archaeology

September 4

Session A

Laboratory techniques applied to archaeology :
Mr. G. F. Mitchell.—*Vegetational environmental studies.*
Mr. E. M. Jope.—*History, archaeology, and petrology.*
Mr. L. Biek.—*Antiquities, ancient monuments, and research on materials.*

Session B

Irish archaeology :
Mr. A. E. P. Collins.—*Neolithic pottery in Northern Ireland.*
Mr. E. Watson.—*Some geographical aspects of the megalithic colonisation of N.E. Ireland.*
Mr. D. M. Waterman.—*Recent excavation and study of castles in Northern Ireland.*

September 5

Archaeology, folk-lore, and sacred tradition, Presidential Address by the Rev. Prof. E. O. James.
Mr. J. B. Arthurs.—*The influence of Celtic belief and custom on some aspects of Irish Christianity.*
Prof. E. M. Wilson.—*Aspects of Westmorland folk-lore.*
Prof. E. Estyn Evans.—*Archaeology in Northern Ireland,* 1921–51.
Mr. P. J. Hartnett.—*Excavations at Fourknocks, Co. Meath,* 1950–2.

September 8

Session A

Foreign archaeology:
Mr. P. L. Shinnie.—*Archaeological problems in the central Sudan.*
Dr. O. Davies.—*Climatic sequence and coastal movements during the Pleistocene in South Africa.*
Mr. W. C. Brice.—*Routes of trade, conquest, and migration in early Anatolia.*

Session B

Irish folk-culture:
Dr. D. McCourt.—*The rundale system in Ireland.*
Mr. J. M. Mogey.—*Kin and neighbourhood in Northern Ireland.*
Mr. D. G. Neill.—*The study of an election in Northern Ireland.*
Mr. A. T. Lucas.—*Some international relationships of Irish folk-life.*

September 9

Mr. J. G. Hurst.—*The study of villages deserted in the Middle Ages.*
Mr. G. B. Thompson.—*Primitive farm transport in Northern Ireland.*
Dr. J. Raftery.—*Contributions to the study of Irish Late Bronze Age gold.*

Dr. H. G. Leask.—*The Irish stone roof in churches.*
The Rt. Hon. the Lord Raglan.—*Recent developments in the study of kingship ritual.*
Mr. B. Sutton-Smith.—*The games of New Zealand children.*

SECTION I

Physiology

September 4

Biology of flying. Joint Session with Section G.
Dr. K. G. Bergin.—*The biology of flying.*
Group Capt. W. K. Stewart.—*Physiological problems of high performance military aircraft.*
Dr. W. E. Hick.—*Skill and the airman.*
Mr. D. G. A. Rendel.—*Engineering problems of conditioning aircraft for human occupation and control.*

September 5

The comparative physiology of muscle. Joint Session with Section D.
Prof. A. V. Hill, C.H., O.B.E., F.R.S.—*Factors involved in the design of muscles.*
Dr. J. Lowy.—*The contractile mechanism of Lamellibranch muscle.*
Dr. G. M. Hughes.—*The neuro-muscular mechanism of the insect leg.*
Mr. B. C. Abbott and Dr. D. R. Wilkie.—*Frogs, men, snails, and dogfish.*
Dr. E. J. Hanson.—*Muscle cytology in relation to functioning of muscles.*

September 8

Nervous control of the movements of the alimentary canal, Presidential Address by Prof. R. C. Garry.
Prof. C. F. W. Illingworth.—*The epidemiology of peptic ulcer.*
Prof. H. W. Rodgers.—*Hepatic injury and its aftermath.*
Dr. A. T. Phillipson.—*The control of gastric movement in the ruminant.*

September 9

Antibiotics in animal nutrition. Joint Session with Section M.
Dr. S. K. Kon.—*Opening remarks.*
Dr. M. E. Coates.—*Mode of action of antibiotics.*
Dr. F. J. Cuthbertson.—*Antibiotics and the animal protein factor.*
Human biochemical genetics. Joint Session with Sections D and J.
Prof. L. S. Penrose.—*Introduction.*
Dr. H. Harris.—*Recent developments in human biochemical genetics.*
Dr. Valerie Cowie.—*Phenylketonuria.*
Dr. S. P. Datta.—*Comparative biochemistry of aminoaciduria.*
Prof. D. C. Harrison.—*Familial methaemoglobinaemia.*

September 10

Energy into nerve impulses :
Dr. E. D. Adrian, O.M., P.R.S.—*Mechanism of olfactory stimulation in the mammal.*
Dr. Hallowell Davis.—*The inner ear.*
Dr. M. H. Pirenne.—*Energy into nerve impulses : visual excitation.*
Dr. J. A. B. Gray.—*Initiation of impulses at some sensory endings.*

SECTION J

Psychology

September 4

Mr. K. F. H. Murrell.—*Fitting the job to the sailor.*
Mr. E. Elliott.—*Problems of classification.*
Mr. D. C. Fraser.—*The problem of transfer of training.*
The assessment of personality, Presidential Address by Prof. P. E. Vernon.
Dr. L. F. Richardson, F.R.S.—*What influences keep the peace at geographically short range?*
Prof. G. P. Meredith.—*Basic mental operations.*

September 5

Factors influencing change in human behaviour :
Prof. C. A. Mace.—*Resistance to change.*
Miss M. Woodward.—*Changes in social participation following the birth of a child.*
Factors influencing change in human behaviour with special reference to the application of scientific discoveries to the agricultural industry. Joint Session with Section M.
Mr. J. M. Mogey.—*Characteristics of a rural community in Northern Ireland.*
Prof. R. Rae, C.B.—*The farmer's attitude to new methods.*
Dr. R. Harper.—*The application of new knowledge and techniques in agriculture.*

September 8

Some social and psychological problems of ageing :
Dr. G. F. Adams.—*Medical-social aspects on ageing in the modern world.*
Miss S. R. Burstein.—*Adjustment and preparation for old age.*
Mrs. A. V. Hill.—*Emotional changes in advanced old age.*
Dr. J. A. Oliver.—*Thinking about old age.*
Mr. A. T. Welford.—*Physical and mental skills of the aged.*
Dr. G. Seth.—*Trends in child psychology.*
Mr. A. Yates.—*The effects of coaching and practice on intelligence test scores.*
Mr. J. McGilton.—*Item selection and test reliability.*

September 9

Some factors affecting choice and judgment :

Dr. R. J. Smeed.—*Some factors influencing the road behaviour of vehicle drivers.*

Mr. R. L. Moore.—*Pedestrian choice and judgment.*

Dr. R. G. Hopkinson.—*The influence of experience on subjective judgments.*

Miss M. A. Phemister.—*The effect of varying the frame of reference upon judgment of spatial direction.*

Mr. B. M. Foss.—*Some factors affecting choice and judgment.*

Dr. J. C. Penton.—*The juvenile delinquent in the Forces.*

Dr. R. S. Allison and Mr. P. McEwen.—*Recovery of cerebral function in a case of severe brain-stem injury.*

SECTION K

Botany

September 4

The anatomy of metabolism in higher plants : metabolic processes and partial reactions, Presidential Address by Prof. Meirion Thomas, F.R.S.

Dr. P. F. Wareing.—*Reproductive development in Scots Pine.*

Dr. H. E. Street.—*The life span of root apices.*

Prof. O. M. Roberts.—*Water uptake of potato leaves from fog.*

University teaching of a botanist :

Dr. Eric Ashby.

Dr. W. B. Turrill.

Dr. P. R. Bell.

Mr. W. Ellis Davies.—*The breeding affinities of some British species of Agrostis.*

Mr. Keith Jones.—*The cytology of some British species of Agrostis and their hybrids.*

Dr. J. Heslop Harrison.—*The variability of Nymphaea alba L.*

Prof. C. T. Ingold.—*The water relations of spore discharge in some higher fungi.*

Prof. J. Bayley Butler, M.B.E.—*The growth of marine algae in an artificial lagoon at Dollywater, Dublin.*

September 8

Session A

The botany of flax :

Major G. O. Searle, O.B.E.—*Introduction. The botany of flax.*

Prof. A. E. Muskett.—*Seed health in relation to flax.*

Dr. A. G. Arif.—*Physiologic specialisation of* Melampsora lini (paper read by Dr. J. Colhoun).

Mr. K. Holly.—*Weed control in flax.*

Session B

Biology of confined sea waters. Joint Session with Section D.

Prof. J. Small.—*Some aspects and implications of quantitative evolution.*

Dr. F. B. Simpson.—*The Scottish Tertiary flora and its relationship to the Ulster and other floras.*

Prof. R. E. Holttum.—*The sympodial habit in tropical monocotyledons.*

Prof. J. Doyle.—*Gynospore or megaspore—a restatement.*

Mr. K. F. Parkin.—*Forests in N.W. America.*

September 9

The Irish fauna and flora. Joint Session with Sections C and D. See Section D.

SUB-SECTION K*

Forestry

September 4

Metabolic processes and partial reactions, Presidential Address to Section K by Prof. Meirion Thomas, F.R.S.

Mr. T. R. Peace.—*Poplar varieties and their silvicultural uses.*

The history of afforestation in Northern Ireland, Chairman's Address by Mr. J. Pimlott, O.B.E.

September 5

The Marquess of Hamilton.—*Estate forestry in Northern Ireland.*

Mr. E. G. Sherrard.—*The reclamation of poor peatland.*

Mr. W. N. Gibson.—*Exotic conifers and their importance to forestry in Northern Ireland and the West of Scotland.*

Prof. Mark L. Anderson.—*Sustention and maximum benefit as elements in forest policy.*

September 8

The afforestation of moorland :

Mr. James Macdonald.—*Modern nursery technique.*

Mr. J. M. B. Brown.—*The role of indicator plants in moorland afforestation.*

Mr. J. W. L. Zehetmayr.—*Recent work on the problems of moorland afforestation.*

Mr. J. A. B. Macdonald.—*The place of* Pinus contorta *in British silviculture.*

September 9

The Irish fauna and flora. See Section D.

SECTION L

Education

September 4

Mr. R. S. Brownell, C.B.E.—*Educational problems in Northern Ireland.*

September 5

Education of Africans in East and Central Africa, Presidential Address by Mr. A. L. Binns, C.B.E., M.C.

Major-General C. Lloyd.—*Higher technological education.*

September 8

Education of the deaf :

Sir Richard Paget, Bt.—*Education of the totally deaf* (read by Mr. E. S. Greenaway).

Mr. R. Askew.—*The higher education of the deaf.*

Prof. A. W. G. Ewing.—*Education of the deaf.*

September 9

Education of backward children :

Mr. E. S. Thomas.

Mr. K. Harrison.

September 10

Research in education. Papers by research students.

Mr. W. H. L. Thornberry.—*Intelligence and attainment among some urban children in Northern Ireland.*

Miss D. J. Phillips.—*The study of the concepts of family life held by a group of adolescent girls.*

SECTION M

AGRICULTURE

September 4

Northern Ireland agriculture :

Prof. A. E. Muskett.—*Agricultural education and research.*

Prof. J. Morrison.—*Animal husbandry.*

Mr. J. C. Baird.—*Crop husbandry.*

September 5

Britain's food supplies, Presidential Address by Dr. N. C. Wright.

Human behaviour with special reference to the application of scientific discoveries to the agricultural industry. Joint Session with Section J.

September 8

Problems of the small farm :

Mr. R. Ede.—*Small farms in Denmark.*

Mr. A. Cromie.—*Practical difficulties as they appear to a small farmer in Northern Ireland.*

Mr. W. H. Cashmore.—*Engineering problems of the small farms.*

September 9

Antibiotics in animal nutrition. Joint Session with Section I.

REFERENCES TO PUBLICATION OF COMMUNICATIONS TO THE SECTIONS

AND OTHER REFERENCES SUPPLIED BY AUTHORS

The titles of discussions, or the names of readers of papers, as to which publication notes have been supplied, are given below in alphabetical order under each Section.

References indicated by ' cf.' are to appropriate works quoted by the authors of papers, not to the papers themselves.

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and 'Dynamo Currents and Conductivities in the Earth's Upper Atmosphere,' *Nature*, in the press; see also 'Research in the Upper Atmosphere with Sounding Rockets,' *J. Br. Interplanetary Soc.*, **11**, 61.

Section B

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Section C

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Section D

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SECTION G

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SECTION H

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Sherrard, E. G. Expected to appear in *Brit. Agric. Bulletin*.

Street, Dr. H. E. To appear in *Physiologia Plantarum* as 'Factors controlling meristematic activity in excised roots. I. Experiments showing the operation of internal factors,' H. E. Street and E. H. Roberts. II. 'Experiments involving repeated subculture of the main axis meristem of roots of *Lycopersicum exulentum*, Mill. and *Lycopersicum pimpinellifolium*, Dunal.' H. E. Street, Moira P. McGonagle and E. H. Roberts.

The Botany of Flax. *Nature*, **170**, 557–9.

Turrill, Dr. W. B. Expected to appear in *Taxon*.

University teaching of a botanist. *Nature*, **177**, 770–78.

Zehetmayr, J. W. L. Expected to appear in *Quar. J. Forestry*. Cf. 'Experiments in planting Upland Heaths,' *Report on Forest Research*, year ending March 1950 ; 'The position of planting on ploughed heathland,' *ibid.*, year ending March 1951 (publication imminent).

Section L

Askew, R. *The Teacher of the Deaf*, Dec. 1952.

Ewing, Prof. A. W. G. Summary, *Nature*, Sept. 27, 1952. Cf. 'Recent developments in the education of deaf and partially deaf children,' *Report of Biennial Conference of Special Schools Association*, pp. 59–64, Sept. 1952 ; 'Speech for Deaf Children,' to appear in *Jour. Manchester Lit. and Philos. Assocn.*

Harrison, K. *Times Ed. Supp.*—in part, Sept. 19, 1952.

Lloyd, Major-Gen. C., *Education*, Oct. 24, 1952 ; Summary in *Electrical Times*, Sept. 11, 1952.

Section M

Cashmore, W. H. Expected to appear in *Br. Agric. Bulletin*, November 1952.

Ede, R. Expected to appear in *Brit. Agric. Bulletin*, November 1952.

Morrison, Prof. J. To appear in *Brit. Agric. Bulletin*.

Problems of the Small Farm. *Nature*, **169**, 740–1.

REPORT OF COUNCIL TO THE GENERAL COMMITTEE, 1951–52

(Received and adopted by the General Committee on September 3, 1952)

Obituary

1. Since the Council's last report the Association has suffered grievous loss by the death of H.M. King George VI (Patron), Sir Charles Sherrington, O.M., G.B.E., F.R.S. (President, 1922), Professor F. T. Brooks, C.B.E., F.R.S. (General Secretary 1935 to 1946,), Professor Allan Ferguson (General Secretary, 1935 to 1946) and the following office-bearers :

Sir Fred Clarke
Sir Hubert Henderson
J. L. Holland
Sir James Irvine, K.B.E., F.R.S.
Commissioner D. C. Lamb, C.M.G.
Dr. E. G. V. Percival
Lord Provost A. Powrie
Prof. H. S. Raper, C.B.E., F.R.S.
Dr. H. S. Rowell, O.B.E.
Prof. N. V. Sidgwick, C.B.E., F.R.S.

On the death of His Majesty King George VI, the Council conveyed to her Majesty Queen Elizabeth II, on behalf of all the members of the Association, a message of sympathy and loyalty which was graciously acknowledged. It is the hope of the Council that Her Majesty will honour the Association by becoming the Association's Patron and an announcement of her wishes is eagerly awaited. [Her Majesty granted her Patronage in a message which was read at the Inaugural Meeting in Belfast by H.R.H. The Duke of Edinburgh.]

The Association was represented at memorial services for Sir Charles Sherrington by the President, Professor A. V. Hill ; for Professor F. T. Brooks by Mr. M. C. Burkitt ; and for Professor Allan Ferguson by Dr. O. J. R. Howarth and the Secretary. The Officers and members of the Council wish to record the Association's great indebtedness to these three past Officers for long years of faithful service, and for the many friendships they inspired.

Relations with other Institutions

2. By the appointment of official representatives, and in other ways, the Association maintained cordial relations with scientific institutions at home. As the Association's representative on the Parliamentary and Scientific Committee, the General Treasurer was a member of a deputation which discussed with the Lord President the greater use of science in industry.

As regards international relations, the Association's overseas contacts have been consolidated and increased. The Council have appointed representatives at International Congresses on Theoretical and Applied Mechanics (Istanbul), Geology (Algiers), Geography (Washington), Archæology and Anthropology (Vienna) and on desert research (Israel). The Association was also privileged to be represented at Annual Meetings of other Associations for the Advancement of Science during the year, namely, at the meetings of the Indian Science Congress Association in Calcutta, by Prof. C. B. Fawcett ; of the Pakistan Association at Peshawar, by Prof. A. V. Hill, Sir Henry Tizard and Sir Ben Lockspeiser ; of the South African Association in Cape Town, by Sir Edward Salisbury and Sir Lawrence Bragg ; of the Australian and New Zealand Association at Sydney, by Sir Edward Appleton. Mr. M. G. Bennett and Dr. George Taylor have been appointed to attend the Annual Meeting of the French Association at Cannes in September.

During the year, through the encouragement of Unesco, collaboration between Associations for the Advancement of Science has been extended. The Ceylon Association and the Burma Science Association have been recognised as members of the International Committee of Associations for the Advancement of Science, and new Associations have been

established in the Philippines and in Venezuela.

At the Belfast Meeting the Association, with generous assistance from the British Council, will entertain officers and senior members of Associations in Australia and New Zealand, France, India, Pakistan, South Africa and the United States of America. Officers of Unesco will also be present and opportunity will be taken to discuss further possibilities of co-operation.

Edinburgh Meeting

3. The attendance at the Edinburgh Meeting in 1951 was 4,012, which constituted a record for a provincial meeting at home. The Association's indebtedness to the Local Executive Committee was greatly increased during the year by their generous decision to make an unconditional gift of the unexpended balance of the Local Fund (approximately £900).

Belfast Meeting

4. Occurring on the centenary of the first meeting in Belfast and fifty years after the third in that City, the 1952 meeting has a special interest, and the Council have greatly welcomed the enthusiasm of local colleagues whose services have been unsparingly devoted to local preparations of which few of those concerned have had any direct previous experience. An innovation of some importance is the arrangement of a daily programme of special interest to school children and other young people as announced in the Programme of the Meeting. The experiment will be watched with great interest.

Future Meetings

5. An invitation to meet in Liverpool in 1953 has already been accepted, and the following Local Honorary Officers have been appointed: Treasurer: Mr. John Ainsworth (City Treasurer); Joint Secretaries: Mr. Thomas Alker (Town Clerk) and Mr. Stanley Dumbell (Registrar of the University). The Council have received from the Local Executive Committee, and recommend for acceptance, a proposal that the meeting be held during the period September 2–9.

The General Committee have already accepted a joint invitation from the City and University of Oxford to meet in that city in 1954. A proposal that the dates be September 1–8 is recommended for approval.

Officers and Council

6. *President*, 1953.—The Council unanimously recommend Sir Edward Appleton, G.B.E., K.C.B., F.R.S., for appointment as President for 1953.

General Officers, 1952–53.—Shortly after the Edinburgh Meeting the Council learned with great regret that Sir Arthur Trueman would not be able to continue as Honorary General Secretary. The Council appointed Dr. George Taylor as his successor.

The Council nominate for appointment as General Officers for the year 1952–53:

General Treasurer: Mr. M. G. Bennett.

General Secretaries: Sir Richard Southwell, F.R.S., and Dr. George Taylor.

Other Members of Council, 1952–53.—During the year Dr. K. G. Fenelon resigned his membership of the Council on taking up an appointment overseas. The Council appointed Mr. S. R. Dennison in his stead. On the death of Sir Fred Clarke the Council appointed Mr. J. Wickham Murray to succeed him as a member of Council.

The members retiring under Statute III, 3, are: Mr. P. Ritchie Calder, Mr. S. R. Dennison, Dr. O. J. R. Howarth, Prof. E. H. Neville and Dr. C. J. Stubblefield. Under the powers given to them by Statute the Council nominate for appointment: Prof. L. F. Bates, Dr. W. E. Swinton and Mr. W. H. Wilcockson, leaving two vacancies in the ordinary membership to be filled by the General Committee without nomination by the Council. If the General Committee approve the following list of nominations one of the two remaining vacancies must be filled by a representative of Section F (Economics):

Prof. F. Balfour-Browne
Prof. L. F. Bates, F.R.S.
M. C. Burkitt
Wing-Comm. T. R. Cave - Browne-Cave, C.B.E.
Prof. H. G. Champion, C.I.E.
Prof. Winifred Cullis, C.B.E.
Sir Alfred Egerton, F.R.S.
Prof. H. P. Gilding

Dr. Ezer Griffiths, O.B.E., F.R.S.
Dr. D. B. Harden
A. Gray Jones
Sir Harold Spencer Jones, F.R.S.
Prof. H. D. Kay, C.B.E., F.R.S.
J. Wickham Murray, O.B.E.
Prof. F. W. Paish
Dr. S. J. F. Philpott, M.C.
Prof. W. J. Pugh, O.B.E., F.R.S.
Dr. J. Ramsbottom, O.B.E.
Lord Rennell of Rodd, K.B.E., C.B.
Prof. L. Dudley Stamp, C.B.E.
Dr. W. E. Swinton
Dr. H. Hamshaw Thomas, M.B.E. F.R.S.
Dr. C. Tierney
Prof. W. Wardlaw, C.B.E.
W. H. Wilcockson
Dr. H. E. Wimperis, C.B., C.B.E.
Prof. A. W. Wolters
Dr. N. C. Wright

[The General Committee approved the above nominations and appointed Prof. K. S. Isles and Sir Ben Lockspeiser, F.R.S. to fill the remaining vacancies.]

Honorary Auditors, 1952–53.—At the last annual meeting of the General Committee Dr. H. J. T. Ellingham and Dr. H. S. Rowell were appointed Honorary Auditors. On the death of Dr. Rowell the Council appointed Sir John Simonsen, F.R.S. to succeed him. The Council recommend the reappointment of Dr. Ellingham and Sir John Simonsen.

Presidents of Sections, 1953

7. The Council report that the following have accepted office as Presidents of Sections for 1953 :

Section	
A	Prof. Harold Jeffreys, F.R.S.
B	Prof. G. R. Clemo, F.R.S.
C	Prof. T. N. George
D	Prof. J. E. Smith
E	Prof. R. H. Kinvig
F	Prof. F. W. Paish
G	Lord Dudley Gordon
H	Prof. M. Fortes
I	Dr. D. P. Cuthbertson
J	Prof. D. W. Harding
K	Prof. J. Walton
L	Mr. Robert Birley, C.M.G.
M	Dr. J. Hammond, C.B.E., F.R.S.

Dr. W. E. Swinton has accepted the Presidency of the Conference of Delegates of Corresponding Societies (see also Section 12 below).

General Committee

8. The following have been admitted as members of the General Committee on the recommendation of Section Committees :

Mrs. H. A. Lake Barnett
Prof. E. J. W. Barrington
Prof. M. Fortes
Prof. J. H. Gaddum
Mr. A. S. Gillespie
Dr. J. Heslop Harrison
Prof. G. P. Meredith
Dr. J. Phemister
Prof. M. H. L. Pryce
Sister Monica Taylor

Assistant Secretary

9. Mr. D. J. B. Copp resigned at the end of September, 1951, on taking up an appointment as Secretary of the Institute of Biology. The staff contrived to carry out the work of the office without a replacement until June 1952, when the President and General Officers appointed Mr. J. M. Robertson to fill the vacancy.

Finance and Development

10. When the General Committee received the last annual report, it was announced that the Council proposed to review the Association's finance with special reference to recurring annual deficits on the General Account and on the Down House Account. The Council received from the General Treasurer a detailed statement on every significant item of income and expenditure and appointed a Committee to examine the statement and make recommendations. The Committee submitted three reports and consideration of these reports has been the main concern of the Council during the past year.

(a) *General Income and Expenditure.*—Having considered the trend of income and expenditure since the end of the war, and taken into account possible future trends, the Council decided at an early stage :

(i) That it was highly desirable that the Association should seek fresh endowment to ensure the accomplishment of its objects, since any other action which could be taken

to increase income or reduce expenditure would not be sufficient to ensure permanent financial stability :

(ii) That expenditure could be reduced but not by enough to bridge the gap without doing serious damage to the services provided by the Association :

(iii) That membership subscriptions should be increased, and that all possible measures should be taken to increase the number of *regular* subscribers.

Subscriptions.—These findings were reported at a special meeting of the General Committee on January 4, 1952, when authority was given to seek Privy Council approval of modified subscription rates, with effect from April 1, 1953, as follows :

	Present Rate	*New Rate*
Member (meeting and publications)	2 gns.	3 gns.
Associate (meeting)	1 gn.	2 gns.
Student (under 25)	10*s.*	10*s.*
Corporate Member	10 gns.	10 gns.
Life Member	25 gns.	30 gns.
Endowment Life Member	—	100 gns.
The Advancement of Science.		
Per copy	6*s.*	7*s.* 6*d.*
Per volume of four parts	1 gn.	25*s.*
Price to Members, Associates and Student Members	1 gn.	1 gn.

The Privy Council subsequently approved the new rates and the Statutes have been altered accordingly.

The General Committee also approved on January 4 a recommendation that Annual Members and Associates should have the option of subscribing at the old rates under a Seven-Year Covenant or at the new rates without a Covenant.

The Council appreciate the possibility that increases in subscription rates may discourage young people from becoming members of the Association and it was for this reason that the student subscription was not altered. It is hoped that it may be possible to arrange with Universities and other employers to encourage attendance at annual meetings by the payment of expenses, or of grants towards expenses, to young scientists who do not qualify for the student rate. The use of Seven-Year Covenants should be attractive to tax-payers and is designed to increase the number of the Association's regular subscribers. It has been difficult to estimate the possible effect of the increase in subscriptions in terms of income since there are annual variations in the numbers of subscribers for one meeting only. In a year with an attendance of 3,000 at the annual meeting the additional income might be of the order of £2,000.

The Council invited life members to make supplementary donations to the Association. The General Treasurer has received and gratefully acknowledges the sum of £567 in response to this appeal.

Other annual income. Action taken by the Council is expected to increase income from the sale of publications and from advertisement revenue.

Expenditure. The Council have reviewed every significant item of expenditure and have taken decisions which will effect savings in stationery, postage, printing and travelling expenses. Economies in printing include a reduction in the contents of the programme of the annual meeting, and economies in travelling expenses include a reduction from first-class to third-class travel by members of Council and Presidents of Sections.

One of the main items of expenditure is the cost of maintaining an office with a small permanent staff and the Council see no possibility of reducing expenditure on salaries and wages.

Endowment. The Council hope that changes in the pattern of income and expenditure resulting from the decisions reported above will improve the balance sheet, but have unanimously agreed that the Association must nevertheless seek further endowment sufficient to guarantee the financial stability required for maintaining and expanding its work. The Council have agreed that an appeal should be made at an appropriate time, and that Down House (see below) should not be included as one of its objects. While it has been agreed that further capital should be sought, the members of the Council are divided in their views on the

nature and the timing of the appeal. The problem is whether capital endowment should be sought to provide a permanent income sufficient to cover administration expenses at the present level or whether the objective should be to collect a sum to be expended on development in a limited number of years. Under the first alternative a steady income from invested capital would provide basic expenses and membership subscriptions could be used for service to science and the members: an appeal could be made as soon as possible. Under the second alternative the sum required might be affected by policy decisions such as the establishment of new Sections and by the amount of the increase in income from membership subscriptions; an appeal would have to be delayed until after the Liverpool Meeting. The Council report these points of view, and invite guidance from the General Committee.

Down House

11. (a) *Annual Report.*—The Darwin Memorial Rooms were visited by 4,497 persons in 1951, as compared with 4,030 in the previous year. The increase, however, was more than accounted for by 1,179 visitors to the Down Village Festival Exhibition which was held in the Rooms during nine days in June. The manuscript of the *Voyage of the Beagle* and one of the notebooks kept by Darwin during the voyage were exhibited in the Dome of Discovery at the South Bank Exhibition during the Festival of Britain. Pictures by Joseph Wright and George Stubbs were lent to the Liverpool and Camberwell Art Galleries for exhibition and a book of Darwin's letters to Lubbock were lent to an exhibition at Bromley. Rainfall and snow records were maintained and communicated to the Air Ministry Meteorological Office and the British Glaciological Society. The amount of precipitation in 1951 was 43·86 in., being the largest recorded since records began in 1937.

(b) *The future of Down House.* In 1928 the Association accepted Down House from Mr. (later Sir) Buckston Browne to be maintained as a national memorial to Charles Darwin. The gift of Down House was accompanied by a sum of £20,000 for the upkeep of the memorial. The money was invested and has been administered as the Down House Fund. The income has never been sufficient to cover expenses and for some years the deficits were made good by grants from the Pilgrim Trust, from special funds administered by the Council, and from general funds. In 1949 the Council decided to meet annual deficits by running down the Down House Fund and at the end of the current financial year the Fund had been reduced to £16,843 19*s.* 10*d.*

The Association has faithfully performed its trust so far, and could continue, by running down the Fund, to do so for a limited number of years, but the Council are now convinced, after many years of serious pre-occupation with this problem and after full discussion during the past year, that the Association should seek relief from this responsibility, so that the Officers and the Council may concentrate on the prime objects of the Association.

With the approval of the Council, the Officers have made continuous efforts to negotiate with other responsible bodies on schemes which might increase the usefulness of the estate to science and solve the financial problem. The schemes included a proposal to develop an adult education centre for the study of the natural sciences. This attracted generous promises of financial support from the Goldsmiths Company and the Carnegie U.K. Trust, but the Ministry of Education were unable to approve work requiring a building licence and the scheme has been abandoned. The estate has been unsuccessfully offered as a site for a University field station, and the National Trust are not interested in property which is inadequately endowed. Two national bodies are at present considering the possibility of using the estate for the good of science, but the result of their deliberations cannot be predicted.

The Council have decided to recommend to the General Committee:

(i) That the future of Down House should be determined, if possible, within twelve months;

(ii) That the Officers endeavour, if possible, to bring to a conclusion

by the end of 1952, discussions with responsible bodies who might be interested in maintaining the Darwin memorial ;

(iii) That the General Committee authorise the Council to take such action as seems best within the next 12 months, including exposing the property for sale in the open market ;

(iv) That, if disposal of the property should make it impossible to maintain Darwiniana at Down House, the Old Study be transferred, if that should prove practicable, to a national museum ;

(v) That repayment of money advanced from general funds of the Association on behalf of Down House up to 1949 should be made a first charge on the Down House Fund.

(vi) That a statement on the probable future of Down House be communicated to the Press so that the Council may be guided by any response to an announcement of the Association's intentions.

Conference of Delegates of Corresponding Societies

12. The Council have received representations from the Corresponding Societies Committee that the Conference of Delegates has been hampered in its work on account of its status in relation to the Sections and by its name. It was suggested that changes might advantageously be made without alteration to the Statutes such as would be required by the creation of a new Section. The Council have accepted the recommendations submitted on behalf of the Corresponding Societies Committee, namely :

(a) That the President and Secretary be given the same status and privileges as the Presidents and Recorders of Sections ;

(b) That the Corresponding Societies should have representation on the Council ;

(c) That the Conference of Delegates of Corresponding Societies should in future be described as The Assembly of Corresponding Societies ;

(d) That the symbol X should be allocated to the Assembly for use in the Programme and in other ways as required.

Biometry

13. The Council have received a proposal for the formation of a Section of Biometry, defined as statistical methodology and its applications to the various fields of science. The proposal was sponsored by the Royal Anthropological Institute, the Biometric Society, the Genetical Society, the Pharmacological Society and the Royal Statistical Society. After consideration of a supporting memorandum the Council have decided not to recommend the establishment of such a Section.

Research

14. Following the Edinburgh Meeting, the Council appointed 13 Research Committees on the recommendation of Sections, and made grants to 6 of them. The Committees, with their terms of reference and membership, are listed in *The Advancement of Science*, No. 32, page 439.

During the year the Council decided, after consulting the Committees of the Sections concerned to discontinue the appointment of separate Committees to administer grants to biological stations, and to substitute one panel to receive and advise the Council upon applications for the use of tables rented at Plymouth, Ferry House (Windermere) and Naples.

The Council have authorised the transfer of the Association's Seismograph No. 1 from Down House to the Science Museum as a historical exhibit, and the transfer of the Gray-Milne Library from Down House to the Science Library.

Memorial Lectures

15. The Norman Lockyer Lecture for 1951 was delivered in November at Queen's University, Belfast, by Professor A. C. B. Lovell, who spoke on ' The Radio Astronomer's Universe ' (*Advancement of Science*, No. 32, p. 351).

Publications

16. *The Advancement of Science* has been published quarterly and has maintained a

circulation of about 3,500 copies per quarter.

The Scientific Survey of South East Scotland, published in the name of the Association by the Local Executive Committee for the Edinburgh Meeting, maintained the high post-war standard of this series. The Association is indebted to Edinburgh for income from sales since the meeting.

Resolutions

17. Following discussions at the Edinburgh Meeting, the Council, on the instructions of the General Committee, communicated the following resolutions to the appropriate Ministries :

(i) That, in view of the increasing pressure upon wild life in all parts of the world, and the need for the encouragement of special measures for its protection, the British Association urges His Majesty's Government to take early steps to apply for membership of the International Union for the Protection of Nature.

(ii) That the British Association reaffirm its grave concern over the proposal to fill in the Bilston Burn with debris from the proposed new coal-mine at Loanhead, Midlothian. This action would destroy for all time what is recognised as the most valuable inland section of Lower Carboniferous rocks in Scotland.

Prizes

18. *South Africa Medal*, 1951. The Council have approved the award of the South Africa Medal to Mr. J. D. Theron of Stellenbosch for an original paper on The Cranial Morphology of Ambystoma Maculatum.

Exhibitioners Essay Prize, 1951. The prize offered by the Council for the best essay by an Exhibitioner on the Edinburgh Meeting was awarded to Mr. D. J. Ward.

Endeavour Essay Prizes, 1952. In the third of the Endeavour Essay Competitions for prizes generously offered by the publishers of *Endeavour* in connection with annual meetings of the Association the successful competitors were : Miss Aileen Forrest (first), Mr. A. Gilchrist (second) and Mr. R. V. Coates (third). Special prizes for competitors under 18 years of age were awarded to Ivor Johnston and to Soli Lam.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1951–52

In presenting the balance sheet and accounts for the year 1951–52 the attention of members is drawn to those figures which are specially significant for the financial future of the Association. Expenses on general account were naturally high in the year of the Edinburgh Meeting, attended by over 4,000 members, and amounted to more than £11,000. Subscriptions, the largest single item of income, reached, on the other hand, the new high level of £5,700. General income also included a gift of approximately £900 from the Local Executive Committee for the Edinburgh Meeting. This gift greatly enhances our debt to our friends in Edinburgh whose liberality and enthusiasm was so much appreciated during the meeting in their City.

The accounts also benefit to the extent of some £300 or more from the self sacrificing labour of the staff who covered the work of the office after the retirement of the Assistant Secretary. We are none the less grateful for such service because we have grown accustomed to it. The result of all this is an adverse balance of little over £200, which is far less than was at one time expected.

The small sum entered in the balance sheet as Life Members' Donations represents a few early responses to the Council's appeal. Since the date of the balance sheet these donations have increased to over £500. There have also been some donations to the general account from Annual Members, and I would thank all who by subscriptions or by gifts have helped the Association on its way.

The Report of the Council contains a statement of action in connection with Down House, where a stubborn financial problem has for many years confronted us. During the year under review expenditure exceeded income by the substantial amount of over £900, which, in common with other deficits in recent years, has been written off against the Down House Endowment Fund. This fund, originally of £20,000, is now reduced to less than £17,000, against which a further charge of several thousand pounds ought in fairness to be made in respect of payments by the Association from its general funds during the early years of possession of the property. All the special funds other than Down House are in a satisfactory state.

The smallness of the general deficit this year should not blind us to the true balance of income and expenditure ; but there is every reason to be confident that the policies recommended by the Council's Finance Committee, pursued with determination, will establish the finances of the Association soundly. It must be possible to meet the growing demand for those services to Science which the Association provides.

M. G. Bennett,
General Treasurer.

Balance Sheet, 31st March, 1952

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

		£ s. d.	£ s. d.
GENERAL PURPOSES :—			
Sundry Creditors		1,677 6 3	
Amounts received in advance for publications		151 8 8	
Membership and Associateship subscriptions in advance		93 6 0	
Amount temporarily held on behalf of Seismological Investigations Committee (Dr. J. E. Crombie's bequest)		1,000 0 0	2,922 0 11
Accumulated Fund			
As per last Account		44,264 0 11	
Less Excess of Expenditure over Income for the year on General Account		213 9 10	44,050 11 1
Life Membership Compositions			
As per last Account		6,672 0 4	
Add Subscriptions received during year		210 0 0	
Add, Life Members' donations		22 16 0	
		6,904 16 4	
Less Amount transferred to Income and Expenditure Account		73 15 0	6,831 1 4
[52,919 17 6]			53,803 13 4
Development Fund			
As per last Account		6,192 17 3	
Add Excess of Income over Expenditure for the year		157 6 10	
[6,192 17 3]			6,350 4 1
SPECIAL PURPOSES :—			
Caird Fund			
Capital		9,928 17 9	
Income and Expenditure Account balance as per last Account	537 14 6		
Add Excess of Income over Expenditure for the year	64 19 7		
		602 14 1	
[10,466 12 3]			10,531 11 10
Toronto University Presentation Fund			
Capital		178 11 4	
Income and Expenditure Account balance as per last Account	5 2 3		
Less Excess of Expenditure over Income for the year	1 6		
		5 0 9	
[183 13 7]			183 12 1
Bernard Hobson Fund (1933)			
Capital		1,093 2 6	
Income and Expenditure Account balance as per last Account	398 4 6		
Add Excess of Income over Expenditure for the year	32 9 1		
		430 13 7	
[1,491 7 0]			1,523 16 1
Leicester and Leicestershire Fund, 1933			
Capital		1,000 0 0	
Income and Expenditure Account balance as per last Account	197 12 2		
Less Excess of Expenditure over Income for the year	44 4 3		
		153 7 11	
[1,197 12 2]			1,153 7 11
Radford Mather Lecture Fund (1936)			
Capital		250 0 0	
Income and Expenditure Account balance as per last Account	29 4 11		
Add Excess of Income over Expenditure for the year	6 14 5		
		35 19 4	
[279 4 11]			285 19 4
Arthur Haydock Bequest (1945)			
Capital		2,215 12 0	
Income and Expenditure Account balance as per last Account	355 12 1		
Add Excess of Income over Expenditure for the year	63 19 11		
		419 12 0	
[2,571 4 1]			2,635 4 0
[75,302 8 9]	Carried forward		76,467 8 8

ASSETS

		£ s. d.	£ s. d.
GENERAL PURPOSES :—			
Investments as scheduled with Income and Expenditure Account, No. 1		52,063 8 8	
Sundry debtors		282 13 3	
Addressing machine, as per last Account	162 0 0		
Less Amount charged to Income and Expenditure Account for the year	40 10 0		
		121 10 0	
Stock of Badges		320 14 1	
Cash at bank		112 3 1	
Cash at bank (Edinburgh)		903 4 3	
[52,919 17 6]			53,803 13 4
Development Fund			
Investments (see Income and Expenditure Account No. 2)		6,152 6 0	
Cash at bank		197 18 1	
[6,192 17 3]			6,350 4 1
SPECIAL PURPOSES :—			
Caird Fund			
Investments (see Income and Expenditure Account, No. 3)		10,328 17 9	
Cash at bank		202 14 1	
[10,466 12 3]			10,531 11 10
Toronto University Presentation Fund			
Investment (see Income and Expenditure Account, No. 4)		178 11 4	
Cash at bank		5 0 9	
[183 13 7]			183 12
Bernard Hobson Fund (1933)			
Investments (see Income and Expenditure Account, No. 5)		1,243 2 6	
Cash at bank		280 13 7	
[1,491 7 0]			1,523 16 1
Leicester and Leicestershire Fund, 1933			
Investments (see Income and Expenditure Account, No. 6)		1,000 0 0	
Cash at bank		153 7 11	
[1,197 12 2]			1,153 7 11
Radford Mather Lecture Fund (1936)			
Investments (see Income and Expendiiture Account, No. 7)		250 0 0	
Cash at bank		35 19 4	
[279 4 11]			285 19 4
Arthur Haydock Bequest (1945)			
Investments (see Income and Expenditure Account, No. 8)		2,465 12 0	
Cash at bank		169 12 0	
[2,571 4 1]			2,635 4 0
[75,302 8 9]	Carried forward		76,467 8 8

Balance Sheet, 31st March, 1952 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

		£	s.	d.	£	s.	d.
[*75,302 8 9*]	Brought forward				76,467	8	8
Corcoran Gift (1946)							
Capital		100	0	0			
Income and Expenditure Account balance as per last Account	3 5 1						
Add Excess of Income over Expenditure for the year	3 5 1						
		6	10	2			
[*103 5 1*]					106	10	2
Down House							
Endowment Fund as per last Account		17,750	18	7			
Less Excess of Expenditure over Income for the year		906	18	9			
		16,843	19	10			
Library Fund		3	11	4			
Sundry Creditors		163	13	2			
Cash overdrawn at bank		746	9	1			
[*17,804 10 7*]					17,757	13	5
[*93,210 4 5*]					£94,331	12	3

ASSETS (*continued*)

		£	s.	d.	£	s.	d.
[*75,302 8 9*]	Brought forward				76,467	8	8
Corcoran Gift (1946)							
Investment (see Income and Expenditure Account, No. 9)		100	0	0			
Cash at Bank		6	10	2			
[*103 5 1*]					106	10	2
Down House							
Investments (see Income and Expenditure Account, No. 10)		17,698	4	0			
Sundry Debtors		9	4	11			
Catalogues in stock, at cost		30	14	6			
Cash in hand		19	10	0			
[*17,804 10 7*]					17,757	13	5
[*93,210 4 5*]					£94,331	12	3

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments, and have inspected the Deeds of Down House.

Approved:
H. J. T. ELLINGHAM
J. L. SIMONSEN
Auditors.

W. B. KEEN & CO., *Chartered Accountants*,
Finsbury Circus House, E.C. 2.
2nd July, 1952.

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1952

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£7,011 8s. 2d. Consolidated 2½ per cent. Stock (Inscribed)	5,401 3 0
	£1,252 16s. 2d. Consolidated 2½ per cent. Stock (Registered)	1,000 0 0
	£4,068 19s. 0d. 3 per cent. Savings Bonds 1955/65	4,088 19 0
	£1,808 0s. 0d. 3 per cent. Savings Bonds 1960/70	1,816 1 8
	£18,400 0s. 0d. 3 per cent. Savings Bonds, 1965/75	19,098 11 9
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54 5 2
	£7,704 6s. 2d. 3½ per cent. War Stock, 1952 or after	7,840 0 9
	£6,768 15s. 7d. 3½ per cent. Conversion Stock, 1961 or after	5,726 8 11
	£4,184 18s. 2d. 2½ per cent. Treasury Stock, 1975 or after	4,184 18 2
	£1,400 0s. 0d. 4 per cent. Funding Loan Stock, 1960/90	1,622 0 0
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock 1955/70	1,000 0 0
	£125 3s. 9d. 3 per cent. British Transport Stock, 1978/88	125 0 0
	£100 0s. 0d. 3 per cent. Defence Bonds	101 0 3
	Post-war Credit, J. R. Solly, deceased	5 0 0
	[*Value of stocks at 31/3/51, £47,440 16s. 10d.*] (Value at 31/3/52, £41,309 13s. 0d.)	
[*52,063 8 8*]		£52,063 8 8

EXPENDITURE

	£ s. d.	£ s. d.
To Heat, Lighting and Power		83 4 6
,, Stationery		608 1 11
,, Part cost of addressing machine		40 10 0
,, Rent		1 0 0
,, Postages		421 9 0
,, Telephone		32 14 5
,, Insurances		11 9 4
,, Travelling expenses	730 11 6	
Less Cost of Recorders' meeting, borne by Edinburgh Local Fund	226 0 4	
		504 11 2
,, Audit for 1950-51		94 10 0
,, Exhibitioners :	174 5 5	
Less Contribution by Liverpool University	50 0 0	
		124 5 5
,, Office furniture		9 8 0
,, Subscription to Parliamentary and Scientific Committee		10 10 0
,, Hire of meeting rooms, equipment, etc.		33 2 8
,, Lift Inspection and Repairs		15 0 0
,, Carriage		22 0 10
,, Reference books, press cuttings, etc.		30 6 2
,, General expenses		43 15 3
,, Panels of armorial bearings		25 3 6
,, Salaries, wages, pensions and National Insurance		4,116 18 11
,, Printing, etc.—		
"The Advancement of Science"	2,777 4 7	
Preliminary Programme, 1951	461 2 2	
Programme, 1951	760 4 2	
Miscellaneous	488 19 10	
		4,487 10 9
,, Norman Lockyer Lecture, 1951 : Fee		10 10 0
,, Hospitality		127 14 8
,, Membership badges used		166 16 6
,, Legal advice, etc.		15 15 0
,, Subscription to International Union for the Protection of Nature		5 0 0
[*10,202 19 9*]		£11,041 8 0

INCOME

	£ s. d.	£ s. d.
By Membership subscriptions		5,744 12 2
,, Life Compositions : amount transferred on expiry of membership		73 15 6
,, Sale of Publications :		
"The Advancement of Science"	590 19 4	
Other items	191 2 0	
		782 1 4
,, Advertisements in B.A. publications :		
"The Advancement of Science"	716 8 4	
Preliminary Programme, 1951	217 0 9	
Programme, 1951	414 18 10	
		1,348 7 11
,, Income Tax recovered to 31st March, 1951 :		
On Interest and Dividends	19 7 0	
,, covenanted subscriptions	85 15 10	
		105 2 10
,, Interest on Investments		1,629 10 2
,, Donations (excluding donations to Life Membership Fund, for which see Balance Sheet)		107 19 0
,, Charges for administration of Special Funds		146 5 2
,, Gift by Local Executive Committee for the Edinburgh Meeting, being surplus of the Local Fund	903 4 3	
Less small accounts payable thereout	12 19 8	
		*890 4 7
[*9,532 17 0*]		10,827 18 2
By Balance, being excess of Expenditure over Income for the year		213 9 10
[*670 2 9*]		
[*10,202 19 9*]		£11,041 8 0

* The Local Executive Committee has promised to add to this gift the amount (not yet determinable) of the proceeds of sale of the "Scientific Survey of South-Eastern Scotland," and Income Tax expected to be recoverable in respect of interest on the Local Fund.

No. 2. Development Fund

An appeal for a Development Fund to be used under the direction of the Council, was made at the Annual Meeting at Dundee in 1947. The fund is still open.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,745 19*s.* 0*d.* London County 2½ per cent. Consolidated Stock, 1960/70	2,750 0 0
	£2,679 1*s.* 6*d.* Bristol Corporation 3 per cent. Redeemable Stock, 1958/63	2,750 0 0
	£454 11*s.* 6*d.* 3 per cent. London County Consolidated Stock, 1956/61	452 6 0
	£292 15*s.* 3*d.* Consolidated 2½ per cent. Stock	200 0 0
[*Value of stocks at 31/3/51, £5,780 1s. 10d.*]	(Value at 31/3/52, £5,148 7*s.* 1*d.*)	
[6,152 6 0]		£6,152 6 0
	Cash at bank	£197 18 1

EXPENDITURE

	£ s. d.		£ s. d.
To Administration charge [*16 19 0*]	17 9 8	By Dividends and Interest	138 13 2
„ Balance, being excess of Income over Expenditure for the year [*152 11 4*]	157 6 10	„ Income Tax recovered	36 3 4
[*169 10 4*]	£174 16 6	[*169 10 4*]	£174 16 6

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,627 0*s.* 10*d.* 3 per cent. Savings Bonds 'A,' 1960/70	2,627 0 10
	£2,716 16*s.* 6*d.* 3½ per cent. War Loan Inscribed Stock	2,516 15 5
	£4,282 18*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	4,785 1 6
	£585 10*s.* 6*d.* Consolidated 2½ per cent. Stock	400 0 0
[*Value of stocks at 31/3/51, £9,193 4s. 5d.*]	(Value at 31/3/52, £7,950 13*s.* 6*d.*)	
[*10,328 17 9*]		£10,328 17 9
	Cash at bank	£202 14 1

EXPENDITURE

	£ s. d.	£ s. d.		£ s. d.
To Rent of tables for 1952 at Biological Stations:			By Dividends and Interest	255 19 8
Naples Zoological Station	50 0 0		„ Income Tax recovered	57 16 4
Freshwater Biological Association, Windermere	50 0 0		„ Unexpended balance of 1950-51 grant, returned	2 2 0
Marine Biological Association, Plymouth	50 0 0	150 0 0		
„ Grants to Research Committees:				
Naples Zoological Station (1950-1951 grant)	50 0 0			
Bury St. Edmunds Skull Site	8 5 4			
Human Geography of Inter-Tropical Africa	1 5 6			
Geographical Glossary	10 0 0	69 10 10		
„ Administration charge		31 7 7		
[*269 14 3*]		250 18 5		
„ Balance, being excess of Income over Expenditure for the year [*32 13 4*]		64 19 7		
[*302 7 7*]		£315 18 0	[*302 7 7*]	£315 18 0
Grants authorised, not yet drawn :—				
Demography, etc., in Inter-Tropical Africa	5 0 0			
Glossary of Geographical Terms	10 0 0			
Kent's Cavern	10 0 0			
Bury St. Edmunds Skull Site	8 16 8			
Selection of Students for Universities	10 0 0			
[*76 0 0*]	£43 16			

No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. From the income a presentation of two bronze medals each year is made, together with presents of books, to selected students in pure and applied science respectively.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	Investment at cost :		
	£175 0s. 0d. 3½ per cent. War Stock	£ s. d.	178 11 4
	[*Value of stock at 31/3/51, £161 0s. 0d.*] (Value at 31/3/52, £136 10s. 0d.)		
[*£178 11s. 4d.*]			£178 11 4
	Cash at bank		£5 0 9

EXPENDITURE			INCOME		
	£ s. d.			£ s. d.	
To Cost of medals for 1951	2 7 6		By Interest	6 2 6	
,, Presents of books, through Toronto University	3 4 3		By Balance, being excess of Expenditure over Income for the year	1 6	
,, Administration charge	12 3				
[*6 5 0*]	£6 4 0		[*6 5 0*]	£6 4 0	

No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	Investments at cost :		
	£50 0s. 0d. 4 per cent. Victory Bonds	£ s. d.	55 10 5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after		601 9 0
	£416 0s. 11d. 3½ per cent. War Stock (Inscribed)		436 3 1
	£178 16s. 4d. Consolidated 2½ per cent. Stock (Registered)		150 0 0
	[*Value of stocks at 31/3/51, £964 4s. 7d.*] (Value at 31/3/52, £826 4s. 11d.)		
[*1,243 2 6*]			£1,243 2 6
	Cash at bank		£280 13 7

EXPENDITURE			INCOME		
	£ s. d.			£ s. d.	
To Administration charge	3 12 1		By Interest	36 1 2	
[*3 12 1*]					
,, Balance, being excess of Income over Expenditure for the year	32 9 1				
[*32 9 1*]					
[*36 1 2*]	£36 1 2		[*36 1 2*]	£36 1 2	
Grants authorised, not yet drawn :—					
Critical Geological Sections	£20 0 0				
Directory of Fossiliferous Localities (Publication by Palaeontographical Society): maximum, subject to review	£170 0 0				
[*20 0 0*]	£190 0 0				

No. 6. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	Investments at cost :		
	£487 2s. 11d. 3½ per cent. Conversion Stock	£ s. d.	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock		500 0 0
	[*Value of stocks at 31/3/51, £899 4s. 11d.*] (Value at 31/3/52, £762 7s. 11d.)		
[*1,000 0 0*]			£1,000 0 0
	Cash at bank		£153 7 11

EXPENDITURE			INCOME		
	£ s. d.			£ s. d.	
To Grant to Committee for Archaeological work in Leicester	75 0 0		By Interest	34 4 2	
[*– – –*]			[*34 4 2*]		
,, Administration charge	3 8 5		,, Balance, being excess of Expenditure over Income for the year	44 4 3	
[*3 8 5*]			[*– – –*]		
,, Excess of Income over Expenditure	– – –				
[*30 15 9*]					
[*34 4 2*]	£78 8 5		[*34 4 2*]	£78 8 5	

No. 7. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£248 17*s.* 8*d.* 3 per cent. London County Consolidated Stock, 1956/61	250 0 0
[*Value of stock at 31/3/51, £248 17s. 8d.*]	(Value at 31/3/52, £230 4*s.* 4*d.*)	
[*250 0 0*]		£250 0 0
	Cash at bank	£35 19 4

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Lecture fee	– – –	By Interest	7 9 4
[*21 0 0*]		[*7 9 4*]	
„ Administration charge	14 11	„ Excess of Expenditure over Income . .	– – –
[*14 11*]		[*14 5 7*]	
„ Balance, being excess of Income over Expenditure for the year	6 14 5		
[– – –]			
[*21 14 11*]	£7 9 4	[*21 14 11*]	£7 9 4

No. 8. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or Botany as may be determined by the governing body of the British Association."

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,090 4*s.* 0*d.* 3½ per cent. Conversion Stock (Registered)	2,215 12 0
	£362 6*s.* 3*d.* Consolidated 2½ per cent. Stock (Inscribed)	250 0 0
[*Value of stocks at 31/3/51, £2,171 3s. 4d.*]	(Value at 31/3/52, £1,845 18*s.* 7*d.*)	
[*2,465 12 0*]		£2,465 12 0
	Cash at bank	£169 12 0

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Grants to Research Committees:		By Interest	82 4 4
[*17 3 1*]			
Committee on Biology in Schools . . .	10 0 0		
„ Administration charge	8 4 5		
[*8 4 5*]			
„ Balance, being excess of Income over Expenditure for the year	63 19 11		
[*56 16 10*]			
[*82 4 4*]	£82 4 4	[*82 4 4*]	£82 4 4
Grant authorised, not yet drawn:—			
Cytology and Genetics £5 0 0			
[– – –] £5 0 0			

No. 9. Corcoran Gift

A gift of £100 received in 1946 for research in memory of Miss J. R. Corcoran.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost:	
	£144 18*s.* 6*d.* Consolidated 2½ per cent. Stock	100 0 0
[*Value of stock at 31/3/51, £99 3s. 8d.*]	(Value at 31/3/52, £86 4*s.* 7*d.*)	
[*100 0 0*]		£100 0 0
	Cash at Bank	£6 10 2

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Administration charge	7 3	By Interest	3 12 4
„ Balance, being excess of Income over Expenditure for the year	3 5 1		
[*3 12 4*]	£3 12 4	[*3 12 4*]	£3 12 4

No. 10. Down House

In response to an appeal made in 1927 by Sir Arthur Keith, F.R.S., then President of the British Association, Mr. (later Sir) Buckston Browne, F.R.C.S., acquired the property of Down House, formerly the home of Darwin, and transferred it with an endowment of £20,000 to the Association expressing the wish that it be held in custody for the nation as a memorial to Darwin.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£3,000 Fishguard and Rosslare Railway and Harbours 3½ per cent. Guaranteed Preference Stock	2,139 17 3
	£9,405 8*s.* 9*d.* Consolidated 2½ per cent. Stock	7,608 9 7
	£2,444 15*s.* 10*d.* 3 per cent. Redemption Stock, 1986/96 (Registered)	2,500 0 0
	£7,380 9*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	5,449 17 2
	Value of stocks at 31/3/51, £17,735 17s. 6d.] (Value at 31/3/52, £15,188 2*s.* 6*d.*)	
[*17,698 4 0*]		£17,698 4 0

EXPENDITURE

	£ s. d.		£ s. d.
To Wages of Staff	1,067 17 10		
,, Rates, Insurance, etc.	39 3 7		
,, Electricity	46 8 3		
,, Fuel, etc.	167 18 6		
,, Drainage	17 12 9		
,, Water	24 1 4		
,, Repairs and Renewals	90 7 5		
,, Land and Garden : materials and maintenance (see opposite)	101 3 2		
,, Household requisites, etc.	12 3 3		
,, Printing, postage, telephone, stationery	42 18 4		
,, Transport, Carriage, etc.	1 9		
,, Cost of Valuation of Property	21 0 0		
,, Administration charge	80 8 7		
[*1,468 11 4*]	£1,711 4 9	[*1,468 11 4*]	£1,711 4 9

INCOME

£ s. d.		£ s. d.
	By Rents receivable	84 10 0
	,, Income Tax recovered to 31st March, 1951	146 17 9
	,, Dividends and Interest	479 16 10
	,, Sale of catalogues, postcards and photographs	15 6 2
	,, Donations received	60 16 3
	,, Sale of hay and garden produce	16 19 0
	[*828 18 5*]	804 6 0
	,, Balance, being excess of Expenditure over Income, transferred to Endowment Fund	906 18 9
	[*639 12 11*]	
[*1,468 11 4*]		£1,711 4 9

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September 3–10, 1952

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CHAIRMAN OF LOCAL EXECUTIVE COMMITTEE

VICE-CHANCELLOR OF THE QUEEN'S UNIVERSITY (Dr. ERIC ASHBY).

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Prof. K. S. ISLES, Queen's University.

LOCAL HON. TREASURER

W. E. CRAWFORD, City Treasurer.

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Membership.—G. R. COWIE.
Publications.—Prof. E. ESTYN EVANS.
Hospitality.—R. B. THOMAS.
Excursions.—RICHARD HAYWARD.
Meeting Rooms.—A. FORRESTER.

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